A METHOD
OF
COMPARING LINES,
AND
DRAUGHTING VESSELS.

POOK.

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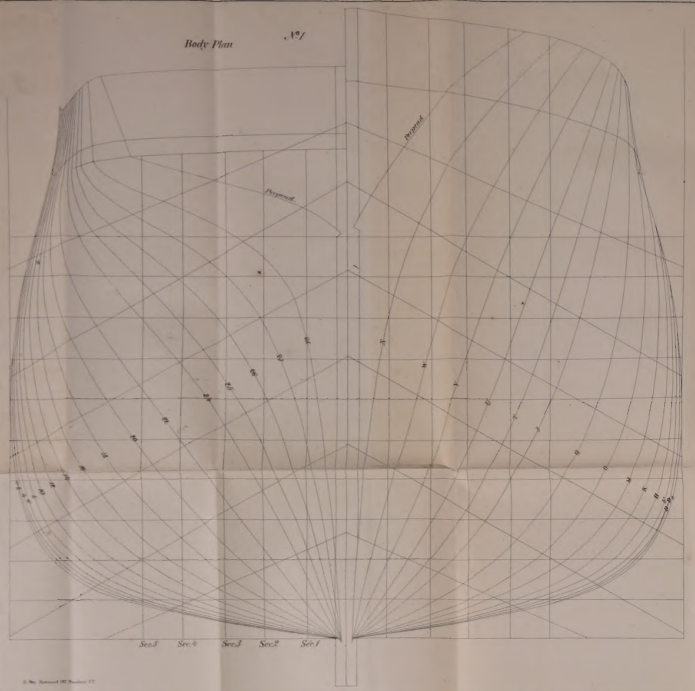
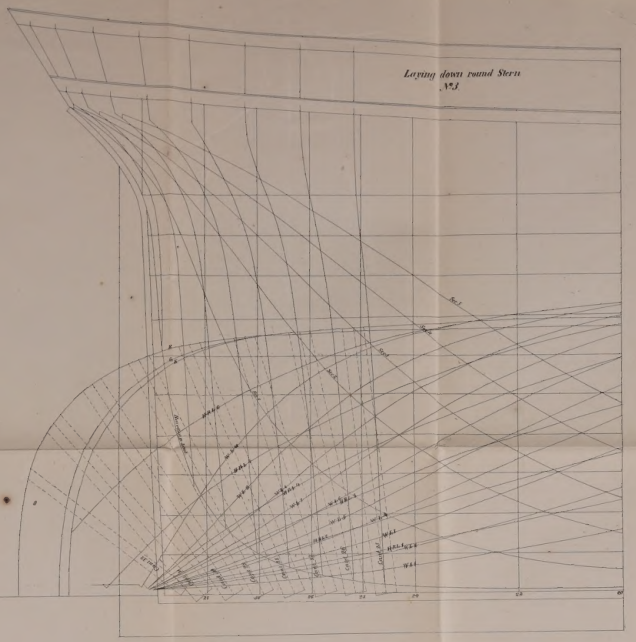
Body Plan .№1



Laying down round Stern
№3



Forward & afterCants for round Sternd. Ship with Bevels
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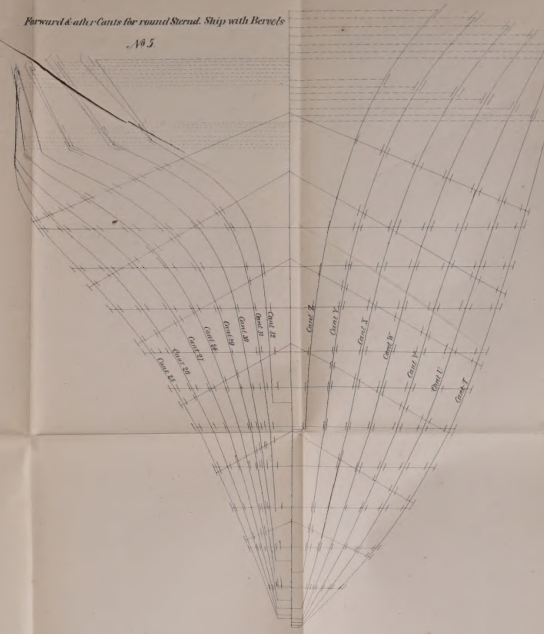

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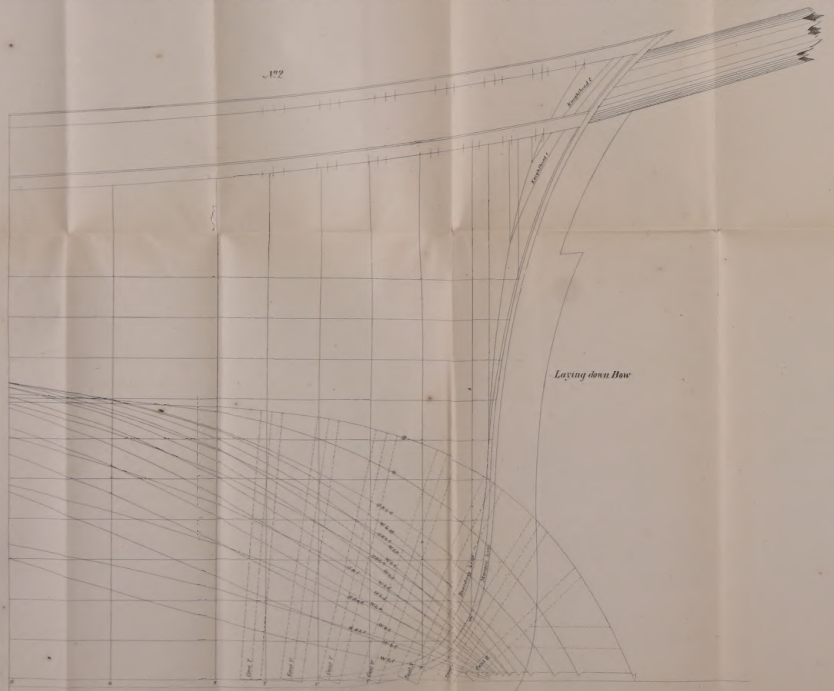
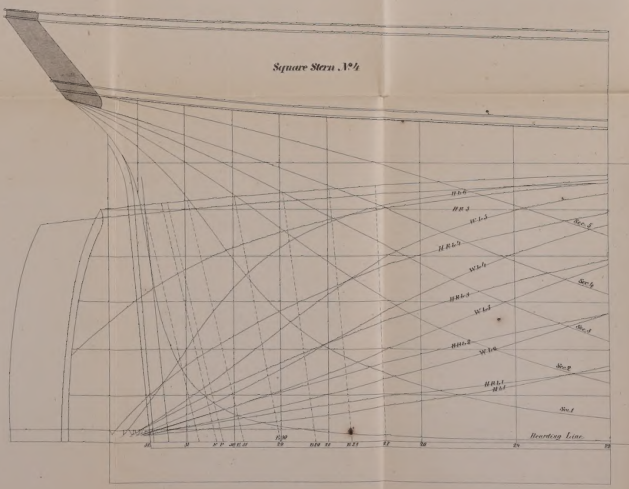
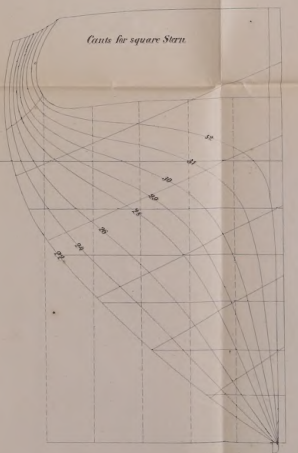


Laying down Bow

Square Stern .№4



Cants for square Stern



A METHOD

OF

COMPARING THE LINES,

AND

DRAUGHTING VESSELS,

PROPELLED BY SAIL OR STEAM.

INCLUDING

A CHAPTER ON LAYING OFF ON THE MOULD LOFT FLOOR.

PEABODY MUSEUM OF SALEM

BY

SAMUEL M. POOK,

NAVAL CONSTRUCTOR.

ILLUSTRATED BY DIAGRAMS.

NEW-YORK:
D. VAN NOSTRAND, 192 BROADWAY.
LONDON: TRÜBNER & CO.

1866.

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To John Baird, Esq., New-York:

Having shown you a Diagram, being my method of comparing lines, which I had prepared for exhibition at the World's Fair in London, 1851, you were pleased to express a desire to have it published for the benefit of the mechanical and commercial world. I have, therefore, taken the liberty of dedicating this Work to you.

Very truly yours,

Samuel M. Pook.

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PREFACE.

Several years ago, I endeavored to ascertain whether the several lines used to obtain the form of the immersed part of a ship's bottom followed any law, and for that purpose compared the relative shapes of the several lines of ships of known good qualities with the various curve lines produced from several diagrams, the basis being a quadrant.

Having discovered that all the lines could be obtained by rule in this manner, and having exhibited my method of obtaining the shapes of the several lines required to form the best ships, to several of my friends interested in this subject, they have been pleased to request their publication. Such was not my original design; but should they be favorably received, and found to meet the wants of ship-builders, it is the design of the author to add, from time to time, such other information as has accumulated in a practice of twenty-five years, and he may consider valuable.

INTRODUCTION.

If a body, bounded either by one curved surface, having all its points subject to the same law, as in a sphere, or by the several parts of different curved surfaces, as in the case of a cone whose surface has been formed in a lathe, be cut up into various sections, an infinite number of curved surfaces will be represented, but some of them will be limited in all directions, and consequently their projections must be limited in extent. The sphere, for instance, is a surface. The extent of its projections on a plane is limited to that of a circle. But all cylindrical surfaces are indefinite in some one direction, similar to the straight lines which generate them. If the only method for knowing the nature of a curved surface was by the two projections of each of the points through which it passes, it would be applicable only to the points of the surface which correspond to the extent of the planes of projection; whilst all those which are beyond those planes could neither be expressed nor known. It is necessary, therefore, to have recourse to some method which shall be consistent with the first, and shall supply that which is deficient. First, every curved surface may be regarded as generated by the movement of a line, either constant in form while it changes its position, or variable at the same time both in form and in position in space; namely,

Cylindrical surfaces may be generated either by the movements of a straight line which always remains parallel to a given straight line, while it moves so as to pass through all the points of a given curve, or by the movement of the curve in such a way that one of its points moving along a given straight line, all its points may describe lines parallel to this straight line; in another curve, the generating line is constant in form, and does not change its position in space. Conical surfaces may also be generated by an indefinite straight line, which always passes through a given point, and moves so that it rests constantly upon a given curve which directs its movements, in this mode of generation, the generating line remains constant in form, never ceasing to be a straight line. A surface of revolution may be generated by the movements of a plane curve, which revolves about a right line situated anywhere in its plane. The generating curve is constant in form, and variable in position only. But we may also regard it as generated by the circumference of a circle which moves so that its centre is always its axis, and its plane perpendicular to its axis, and which expands or contracts so that its radius at each instant is equal to the distance between the two points in which the plane of the circle cuts the axis and a given point in space. The generating curve in this way changes at the same time both its form and position. It is, therefore, evident that all curved surfaces may be generated by the movement of certain curved lines, and that there is not any surface where form and position cannot be completely determined by an exact and complete definition of its mode of generation.

The form and position of curved surfaces is not determined by knowing the projections of the particular points through which they pass; but having constructed the

generating curve through any point according to the form and position which belong to it, in passing through this point, each curved surface may be generated in an infinite number of ways. I have, therefore, selected that which employs the most simple curve, and which involves considerations the most easily understood. Experience has taught us that instead of regarding a curved surface as generated by one curve in one particu lar manner which requires a knowledge of the law of the curve's motion, and also its change of form, it is preferable to consider two different methods of generating the surface at the same time, and point out the construction for the two generating curves through each point. The plan which I have adopted is as follows: Draw a base-line and erect a perpendicular; then with the compasses, fixed at the point of intersection at the base, draw a quadrant of any convenient radius upon the left hand, intersecting the base and perpendicular lines; then, with the same radius, with the point at the intersection of the quadrant with the perpendicular, draw a quadrant which will be the reverse of the first quadrant; now divide the arc of these two quadrants into ten equal parts, and number the left-hand from 1 to 10, and the right-hand quadrant from 10 to 100, and also divide the space between 9 and 10 on the left-hand quadrant into ten equal parts. Now a first line being drawn from No. 10 on the perpendicular to any number on the right-hand quadrant will designate the number of the curve line to be described. Then, from the point of intersection of this line with the quadrant to the perpendicular on the base-line, let the space be divided into ten equal parts, corresponding with the divisions on the left-hand quadrant, from which divisions let straight lines be drawn across the perpendicular line to their corresponding numbers on the

quadrant. Then, supposing the divisions from 10 to 9 on the left-hand quadrant represent 100 parts, the number of the curve line to be described is drawn from the left of the perpendicular to the intersection at the base-line. The measurements are then taken off from this last line where the ten divisions intersect it, to the left-hand quadrant, and set off upon a plane representing ten equal divisions, corresponding with the divisions on the quadrant. Then, through the points so set off, let a curve line be drawn and numbered to designate it as before stated. In like manner, all the curve lines may be drawn from No. 1 to 100. The area of all the lines are carefully measured, and the proportion which they bear to the circumscribing parallelogram are set down in a table opposite each number, and from which tables may be selected the proper numbers to form a ship's body of any required capacity, as may be seen by inspecting the tables. The midship transverse section is measured off from the perpendicular line in lieu of the inclined lines, and if any lines are required sharper than is here described, they may be taken off as follows: Produce the curve line of the right-hand quadrant to a semicircle, and continue the divisions to 200, and continue to draw in the lines as before, and all the horizontal lines will be obtained used in forming the ship's bottom, whatever be her form or capacity.

DELINEATING AND COMPARING THE FORMS OF SHIPS.

We propose that vessels that have actually sailed on the ocean are to be regarded as experiments, and more or less successful according as they have proved to be good sailers and good sea-boats. The vessels then of various sizes and models, of the mercantile and naval service, which have gained the highest reputation for their good qualities, are brought together, and compared in the following manner, and upon the following principles:

All vessels are contained between their two extremes of length, or the two perpendiculars (forward and aft) and their extremes of breadth.

For every vessel separately, let these two measures of length and breadth be taken as the units, or thousandths of measurement, in parts of which all the other dimensions are to be expressed.

Now in general, the relative capacities of vessels depend upon the form of the transverse middle section, which gives the greatest breadth of beam, and the depth of the hold. But the upper part of a vessel (her top or upper works, so called) is very much regulated by fancy, or by convenience, and especially by the latter in mer-

chant vessels, where the object is to carry a very large cargo with a very small tonnage measurement.

That part of the form of the vessel upon which her essential qualities of capacity, speed, and stability depend, is below the surface of the water.

This transverse section is therefore taken from the load water-line down, and the greatest breadth of this section is assumed to be one fourth of the length between perpendiculars, (or length of the load water-line,) and the height of this breadth from the keel is assumed to be two fifths of the breadth above the top of the keel, this distance having been derived from a comparison of all the best forms and models of vessels.

The experiments of "Beaufort" lead to the conclusion that floating bodies move most rapidly through the water when the greatest breadth is two fifths of the distance from the forward to the after extremity, or two fifths of the length from forward, aft. This conclusion is stated by the experimenter in the most general terms. The point, therefore, at which the transverse section is taken will be two fifths from the forward perpendicular, and the top of that section, or the height of the load water-line from the keel will be two fifths of the breadth of the section. Let this section be divided into five equal divisions from top to keel, that is, horizontal or parallel to load water-line.

Thus the middle transverse section will be subdivided into five parts, becoming successively smaller as the top part, the next to the top part, etc., is removed. Next set off the station of (⊠) dead flat in the sheer and half-breadth plan which, as was said before, is two fifths abaft forward perpendicular—mark this point ⊠, which is the starting-point for measurements. Divide the line from ⊠ forward and aft into ten equal parts, and number the divisions from No. 1 to 10 before and abaft ⊠.

FIGURE 15.

Scale of Equal parts

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This two fifths from perpendicular is found to include the greatest breadth of every vessel's greatest transverse section. Though vessels differ very much as to length of floor, the two fifths point may be found either in the forward or after part of the floor of the ship. Having made the divisions as above, we next proceed to measure the comparative shape of the greatest transverse sections of several vessels on the five horizontal lines, by a scale of equal parts (see Fig. 15) made to the greatest breadth, (assuming in all cases the greatest breadth as unit.) These measurements in one vessel may then be compared, as to form and proportion of diminish from the load water-line down, with similar measurements in other vessels. Then at the same point of elevation, two fifths of breadth above the keel, the horizontal plane of the vessel is measured. This horizontal outline exhibits the length and breadth at the load water-line. Its proportional diminish forward and aft may be measured by the same scale of equal parts, and compared as before stated with the load water-line of other vessels. Then let a horizontal outline be taken at each of the five divisions, or successive parts into which the perpendicular line of the transverse section is divided, and at each of these divisions make a horizontal section, or outline, or shape of the line similar to the load water-line ; being the outline, or horizontal plane of each division from the top of the keel to the load water-line. A scale of equal parts is made to each horizontal division on the greatest transverse section, so that the proportional diminish of each horizontal line may be expressed in terms of the greatest breadth of each line. We shall have then five horizontal outlines, corresponding to the five divisions into which the transverse sections are separated, and we shall have ten

transverse sections forward and ten transverse sections abaft the middle section in the sheer plane.

In each of the horizontal planes the breadth of ⊠ is the unit of measure, and in each plane of the greatest transverse section the breadth is expressed in terms of its greatest breadth, or, in other words, the ten transverse divisions of each line before and abaft the midship section are expressed in parts of its greatest breadth at ⊠, and the five divisions on each of the greatest transverse sections are expressed in parts of the greatest breadth on that plane, so the outline form of horizontal plane at load water-line is obtained or reduced; and again the planes of each water-line, or half-breadth planes, are obtained in the same way, only using the breadth at ⊠ of each plane successively for unit of measure.

Here, then, we have arrived at a mode of expressing the form or model of a vessel in exact measures of length and breadth, and these numbers being tabulated, the measures may be taken from numerical tablets, and laid down by a rule of inspection. I have made such tablets. The figures are decimals of the measures above stated. They are derived from a comparison of the best models, and may be considered as a mean of the individual proportions of the whole set. In order to facilitate this comparison, the models are brought together on one drawing, by assuming all the vessels to be one and the same measure of breadth, and laying off the successive horizontal outlines for each of the vessels compared by its own decimal.

A peculiar scale is also constructed, by means of which the measures may be taken in the compasses instead of out of the tables. This is for the convenience of draughting.

The foregoing description shows that by a comparison

of many of the most approved models of vessels of well-known qualities, instituted for the purpose of discovering whether any law had actually been undesignedly followed in the construction of good ships, or deducing, if possible, a new law by which such construction could be hereafter regulated, I have invented a plan by which is accomplished two things: First, is acquired a definite perception of the relations or proportions which several selected models have to each other in all their parts. Second, I lay down a new plan or method of constructing vessels of all classes and of all kinds, which is simple and comprehensive, which embraces all details of form, and combines in a mean ratio or degree all the features and peculiarities of form of those ships which are known to have performed well.

And this plan is, as is said above, applicable to vessels of all sizes and classes; for, by increasing or decreasing the length or breadth of beam, and thus changing the relative proportions, the result will be a different model, varying from the broad and full ships of the line, to the sharp clipper-schooner and the attenuated river-steamer. The place of the greatest breadth may be altered from the standard of two fifths, which gives the utmost latitude as to form. In North River steamers, the greatest breadth is amidships.

It appears that by comparing the shape of all the best-formed vessels, the lines composing the form of a ship may be described as follows:

1st. All the greatest transverse sections of vessels are of a circular or elliptical form at or near the load water-line, terminated by a straight line forming an angle with the middle line at the bottom, or near the keel.

2d. That all the horizontal lines cutting the ship parallel with the load water-line below this line of floata-

tion are of an elliptical form amidships, joined to and terminating in a straight line forming an angle with the middle line at the ends.

3d. That the upper or load-line partakes more of the form of the ellipse at the ends connected by a straight line nearly parallel with the middle line amidships, while the lines near the keel have more of the straight line, or angular at the ends, joined by an ellipse at the centre.

As the conic sections are of utility in explaining this method, a brief definition is here inserted.

A cone, in geometry, is a solid figure having a circle for its base, and is terminated in a point or vertex. A right cone may be supposed to be generated by the revolution of a right-angled triangle about its perpendicular leg, considered as an axis. The curves that generally pass under the name of conic sections are three, namely, the Ellipse, Parabola, and Hyperbola, (for although the triangle and circle are formed by the vertical and horizontal sections of a cone, yet they are not usually considered as conic sections;) and if a right cone be cut off parallel to its base, that section will be a circle, *because* the base is a circle. If a right cone be cut anywhere by a right line that cuts both its sides, but not parallel to its base, the plane of that section will be an Ellipse, (or oval,) that is, an oblong, or imperfect circle, having several diameters and two particular centres.

If a cone be cut parallel to one of its sides, the plane of the section is called a Parabola; but if it be cut anywhere by a right line, either parallel to its axis or otherwise, in such a manner that the intersecting line, when continued through one side of the cone, will meet with the other side of the cone if it be continued beyond the vertex, then the plane is a Hyperbola.

From the genesis of these sections it may be observed

how one section degenerates into another, for an Ellipse being that plane of any section of the cone which is between the circle and Parabola, it will be easy to conceive that there may be a great variety of Ellipses produced from the same cone, and when the section comes to be exactly parallel to one side of the cone, then the Ellipse degenerates into a Parabola.

Now a Parabola being a section whose plane is always exactly parallel to the side of the cone, cannot vary as the Ellipse may, for so soon as it begins to move out of that position of being parallel to the side of the cone, it degenerates either into an Ellipse or Hyperbola. Therefore, there may be as great a variety of Hyperbolas produced from one and the same cone as there may be Ellipses. In short, a circle may change into an Ellipse, the Ellipse into a Parabola, the Parabola into an Hyperbola, and the Hyperbola into a plane triangle, and the centre of the circle, which is its focus, divides itself into two focuses or foci, so soon as the circle begins to degenerate into an Ellipse; but when the Ellipse changes into a Parabola, one end of it flies open, one of its foci vanishes, and the remaining focus goes along with the Parabola, until the latter degenerates into a Hyperbola; and when the Hyperbola degenerates into a plane triangle, this focus becomes the vertical point of the triangle, namely, the vertex of the cone, so that the centre of the base of the cone may be said to pass gradually through all the sections until it arrives at the vertex, still carrying its parameter along with it.

The Parameter is that constant right line which passes through all three conic sections; for the diameter of a circle being that right line which passes through its centre or focus, and by which all other right lines drawn within the circle are regulated and valued, may be called

the parameter of the circle; and though it loses the name of diameter when the circle degerates into an Ellipse, yet it retains the name of parameter in all the sections, generally shortening as the focus carries it along from one section to another, until at last both it and the focus become coïncident, and terminate in the vertex of the cone.

Now from the segments of circles and various elliptical curves may be found the moulds used for constructing the draughts and plans of ships as follows:

To construct a scale of curve-lines suitable for delineating the forms of the water-lines of a ship, proceed as follows: (Fig. 1,) Draw a base-line (A. B.) and erect a perpendicular (E. F.) at the centre E. for a middle line; then set off D. and C. equal distances each side of the middle line, and draw the lines A. D. and B. C. parallel with E. F., and let C. B. and A. D. be equal to A. E., and we shall have a parallelogram A. B. C. D., of which the sides A. D. and B. C. are one half of the sides A. B. and C. D. Now, in the left-hand square A. E. D. F. with E. as a centre, and E. A. as radius describe a quadrant, and in the right-hand square E. B. C. F., with F. as a centre and F. E. as radius, describe a reverse quadrant, and divide the arc of each quadrant into ten equal parts from A. to F. and from E. to C., and number those on A. to F. 1, 2, 3, 4, 5, etc., commencing at A., and number those on E. C. 10, 20, 30, etc., commencing at E.; next draw lines from 1, 2, 3, 4, 5, etc., to E. on the base line, also draw lines from 10, 20, 30, etc., to the same point E. on the base-line, and a great variety of curve-lines may be obtained, as follows:

Draw a base-line E. F., (Fig. 2,) and erect ten perpendicular lines E. 1, 2, 3, etc., corresponding in number with the divisions on the arc A. F.; then if the distance be taken from the point E. to any section on the arc A. F.,

FIGURE 1

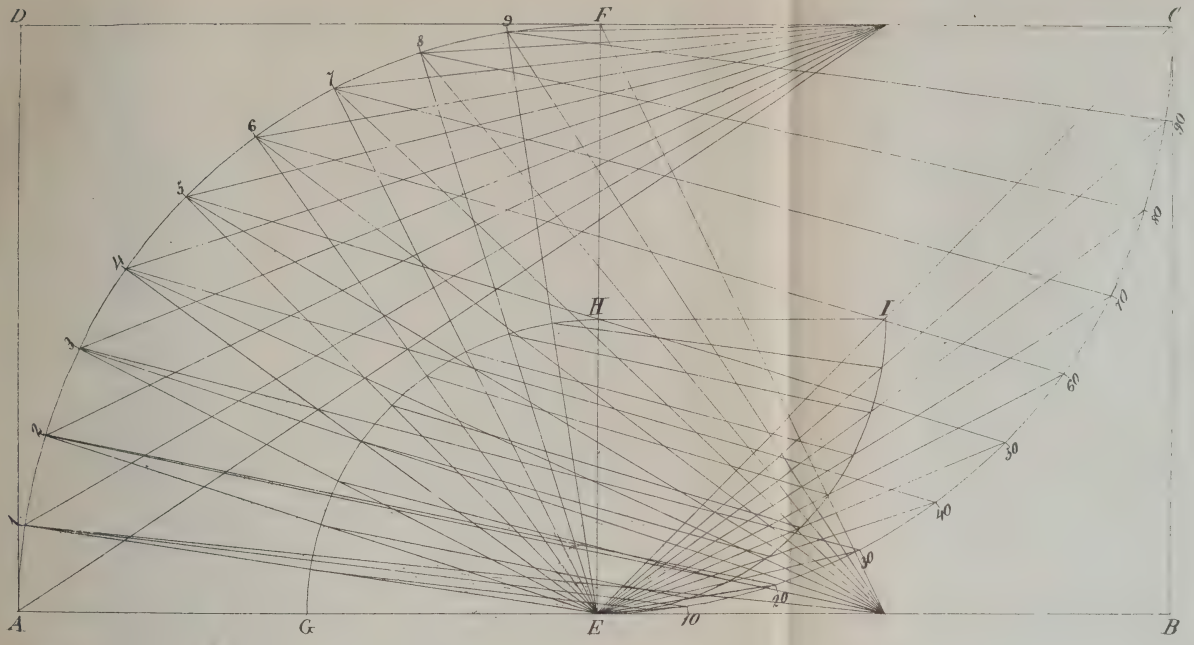
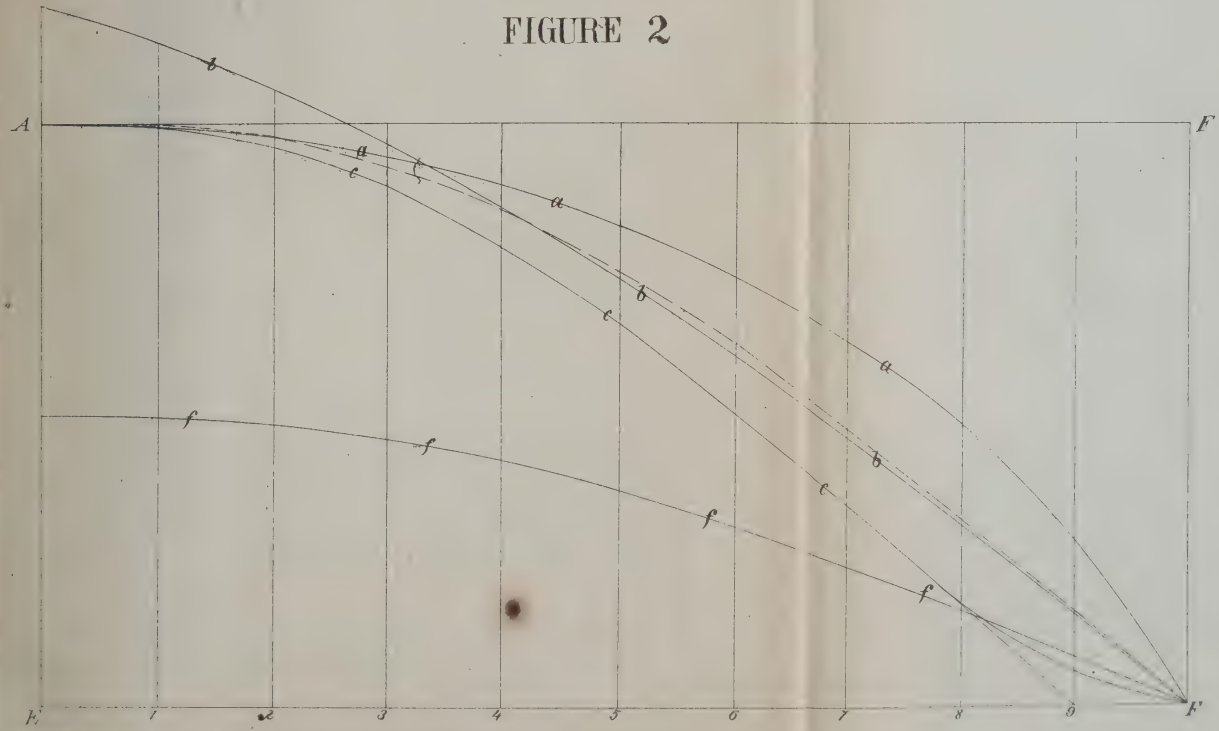


FIGURE 2



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and set off on corresponding sections in Fig. 2, a line drawn through the spots will be a straight line A. F. But if from those divisions on the arc A. F. be drawn lines to any point on the base-line between E. B., and the distances be taken from where those lines intersect the line E. F. to the arc of the quadrant A. F., and set off upon their corresponding sections perpendicular to the base line E. F. in Fig. 2, and a curve-line be drawn intersecting the spots so set off, it will be a semi-ellipse, as a. a. a. But if the sections from the same quadrant A. F. be drawn to any point between F. C., and measured off from where they intersect the line E. F. to the arc A. F., and these distances transferred to Fig. 2 as before, a curve-line passing through the points so transferred, will be a semi-hyperbola as b. b. b. Now, if the sections on the arc of the quadrant A. F. be drawn to the corresponding section on the arc of the quadrant E. C., and the distances be measured off as before from E. F. to A. F. and set off in Fig. 2 on their corresponding sections, a curve-line passing through the points so set off, will be a curve-line partaking of both the curves first drawn, namely, elliptical at one end, hyperbolical at the other end, as shown by the dotted line, or an ellipse joined to a straight line, which is the curve required for the horizontal lines of a ship.

It will readily be perceived by inspecting the diagram, that the curve-lines may be varied at pleasure, becoming sharper or more acute-angled with the middle line E. F. on Fig. 2, as the divisions on the arc E. C. are separated, and farther from the middle line, while the lines are more elliptical as they approach the centre, or base line, and the divisions are less.

If the measurements be taken off from the line E. G., instead of E. F., and set off from the base-line E. F.

(Fig. 2) on the corresponding perpendicular sections, the curve may be varied and shortened at the end to suit the lower water-line to correspond with the rake of the stem of the ship as c. c. c.

Now, if a quadrant of less radius be drawn within the first, as G. H. E. and E. H. I., and measured off as before, and transferred to the sections of Fig. 2, a curved line will be formed similar to the dotted line above described, but finer; the area of the surface, however, is the same in proportion to its circumscribing parallelogram as f. f. f. The best lines for velocity may be constructed from this diagram; and with the above explanation, we will proceed with a description of the method of forming ship's bodies from it, as follows:

Let us construct the parallelogram, (Fig. 3,) with the quadrants and divisions upon the arc of each set off and numbered as before described in Fig. 1, and proceed as follows:

Select from the table on page 32, from the combination of numbers from column numbered 11, suitable for a sloop-of-war, (⊠=50,) 16, 25, 30, 36, 50, 65, and 85, and proceed as follows:

First, determine upon the shape of the greatest transverse section, which in this case may be 50. The numbers selected for each horizontal or water-line are as follows:

5th water-line	Aft	16	Fore	25
	"	30	"	36
	"	50	"	50
	"	85	"	65
	"	80	"	80

Note, 1854. These same lines I would select for a propeller of the first class, 275 long, 55 beam, ⊠=8.

To construct the midship section ⊠, let a first line be drawn (on Fig. 3) from F. to 50 on the arc E. C., and let the space between 50 and E. be divided into ten equal

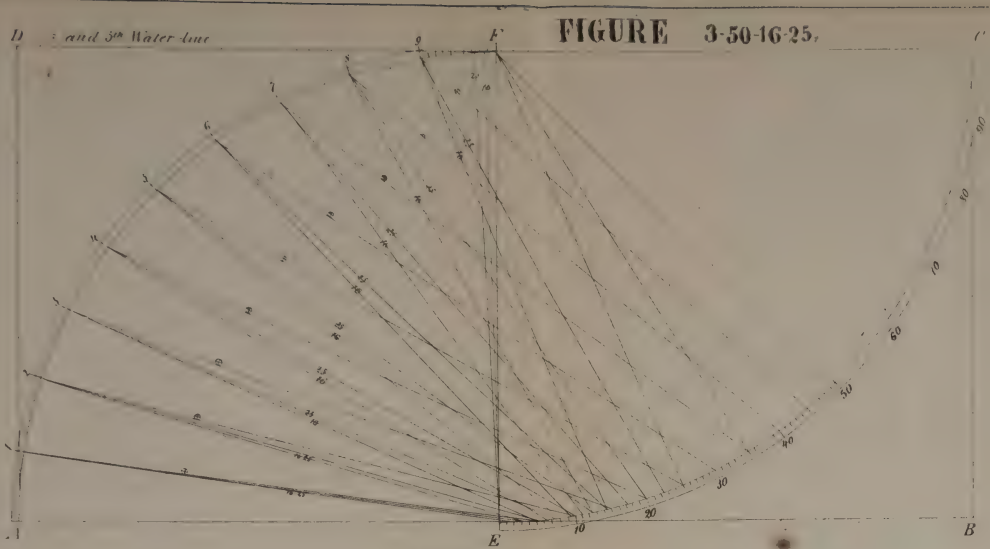


FIGURE 3-50-16-25.

FIGURE 4

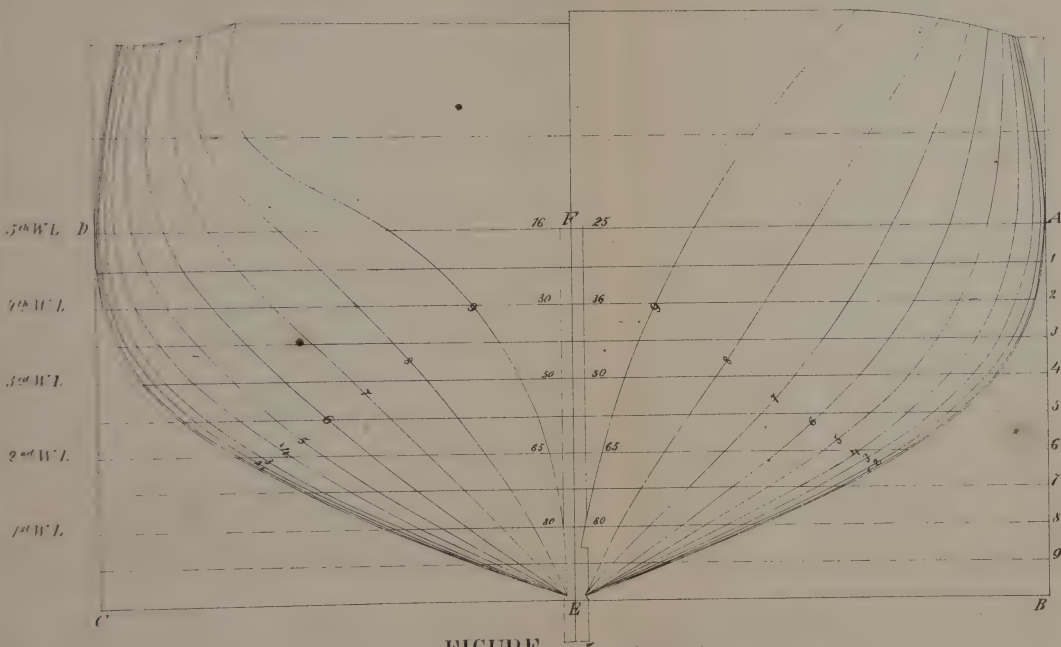
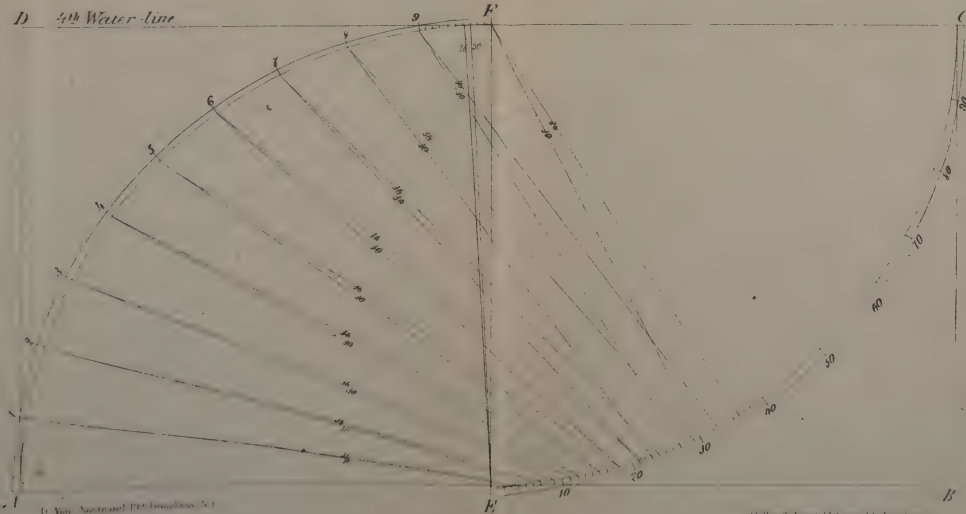


FIGURE 5 30-and 36.



parts to correspond with the number of sections on the arc A. F., and draw lines from the sections on the arc A. F. to the divisions on the arc E. 50. Now construct the parallelogram, (Fig. 4,) A. D. B. C., the sides D. C. and A. B. equal two fifths of D. A., and erect a perpendicular E. F., dividing it in two equal parts; then divide the space B. A. and C. D. each into ten equal parts, and draw lines to each division parallel to A. D., and number them the same as the quadrant A. F. Then from Fig. 3, measure off the distance from where the lines intersect E. F. to the arc A. F., and transfer those measurements to the Fig. 4, and set them off on their corresponding sections from the middle line E. F., and a curve-line drawn through the spots will represent the shape of the greatest transverse section or ⊠ below the load water-line. The side may be continued up one half the distance between E. F. to suit the fancy of the constructor, or the object for which the ship is designed.

Next, the shape of the load, or fifth water-line, may be taken from Fig. 3 and transferred to Fig. 4, as follows:

Let a first line be drawn from F. to 25 on the arc E. C., divided in ten parts to correspond with the sections on A. F., and the lines being drawn as before described, the measurements may be taken from where they intersect the line 25 E. to the arc A. F. and transferred to Fig. 4, and set off from F. on the line F. A., which will be the points where the several transverse sections intersect the fifth water-line forward. Next draw a line from F. to 16, (Fig. 3,) on the arc E. C., and divide that space into ten equal parts; then, from where the lines drawn from the sections on the arc A. F. to the divisions on the arc E. 16 intersect the line 16 E., measure off the distances and transfer them to the Fig. 4, and set them off from the line E. F. on the line F. D., making a spot at each measurement so

set off, which will be the place of the several sections on the fifth water-line aft.

Now, to prevent confusion, we will construct a separate diagram for each of the other water-lines as follows: Take the distance from the line E. F., Fig. 4, on the fourth water-line, to where it intersects the greatest transverse section, or ⊠, and with this distance as radius describe a quadrant, and construct a diagram similar to Fig. 3, (see Fig. 5;) also take the distance at the third water-line, and construct a diagram in a similar manner, (Fig. 6.) Construct a diagram likewise for the second water-line with its distance, Fig. 7, and for the first water-line, Fig. 8.

In every case the breadth of the greatest transverse section at each horizontal line is the radius for its corresponding quadrant from which its horizontal shape may be taken.

Now, on Fig. 5 draw a first line from F. to 36, the number selected for the shape of the fourth W. L. forward, and divide the space from 36 to E. Draw lines from the arc A. F., and measure off the distances from where these lines intersect the line 36 E. to the arc A. F., and set them off on fourth W. L. of the body plan, Fig. 4, from the line E. F. toward A., making a spot at each place. In like manner draw a first line from F. to 30, and having made the divisions on the arc from E. to 30, and drawn the lines from A. F. to those divisions, measure off from where they intersect the line 30 E. to the arc A. F., and transfer the measurements to Fig. 4 of the body plan on the fourth W. L. of the after body, making spots at each point so set off, which will be the place where the several transverse sections cut this horizontal line. We will now proceed in the same manner with the third W. L., second W. L., and first W. L., and having

FIGURE 6-50.

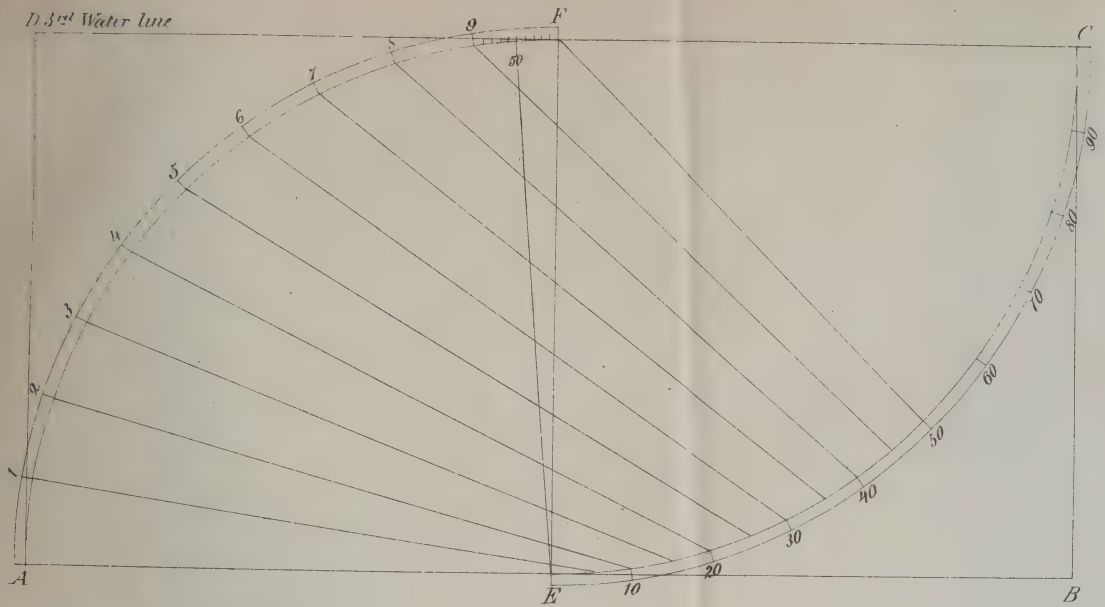


FIGURE 7-65.

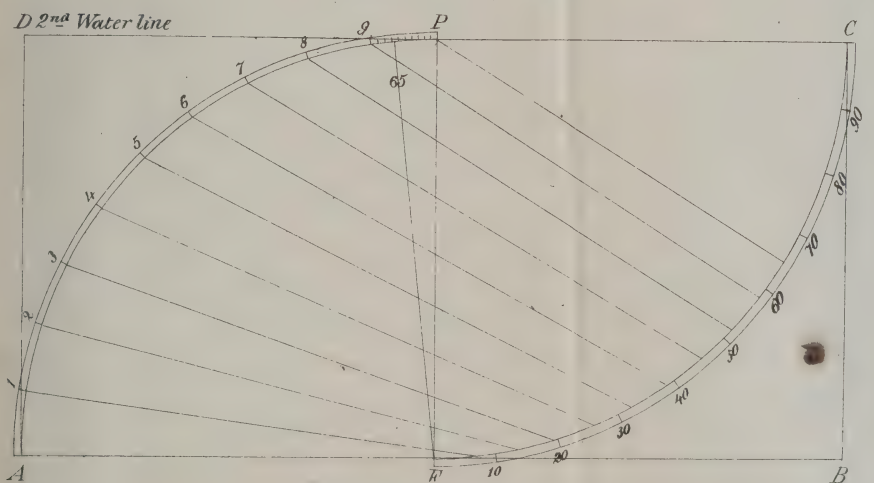


FIGURE 8-80.

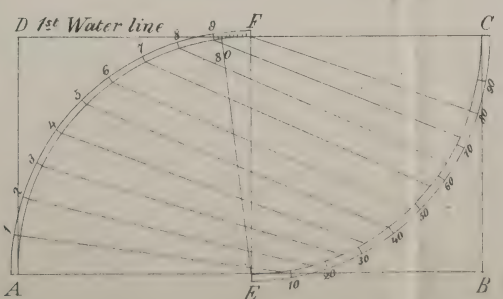


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FIGURE 9

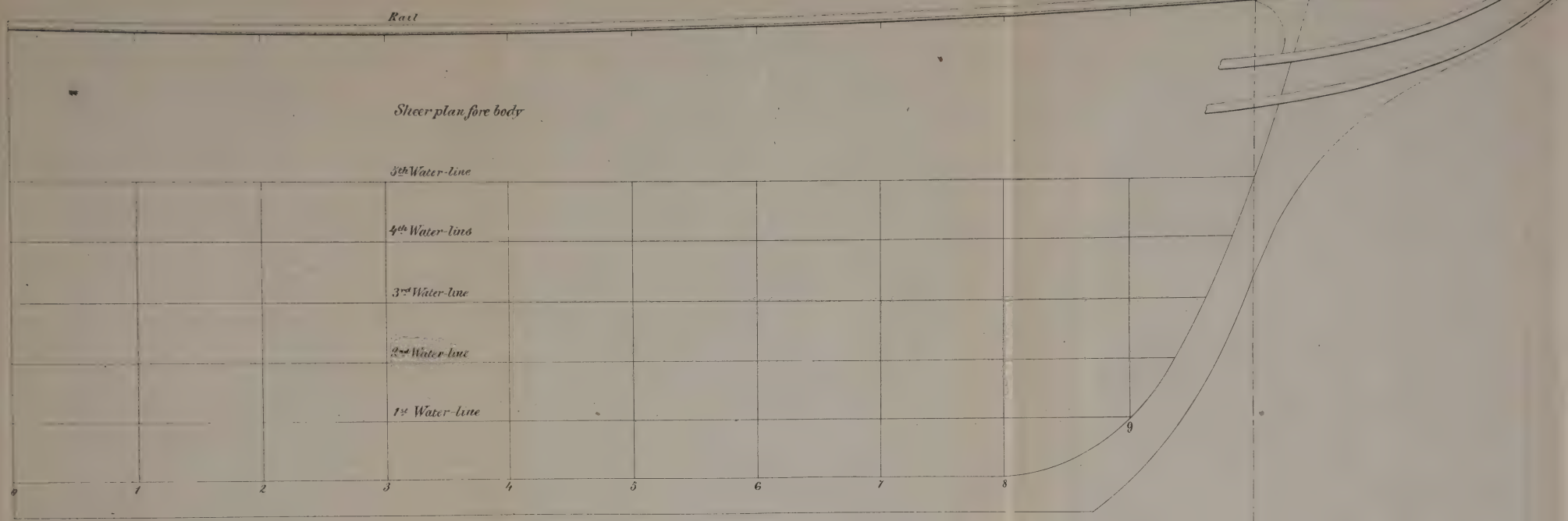
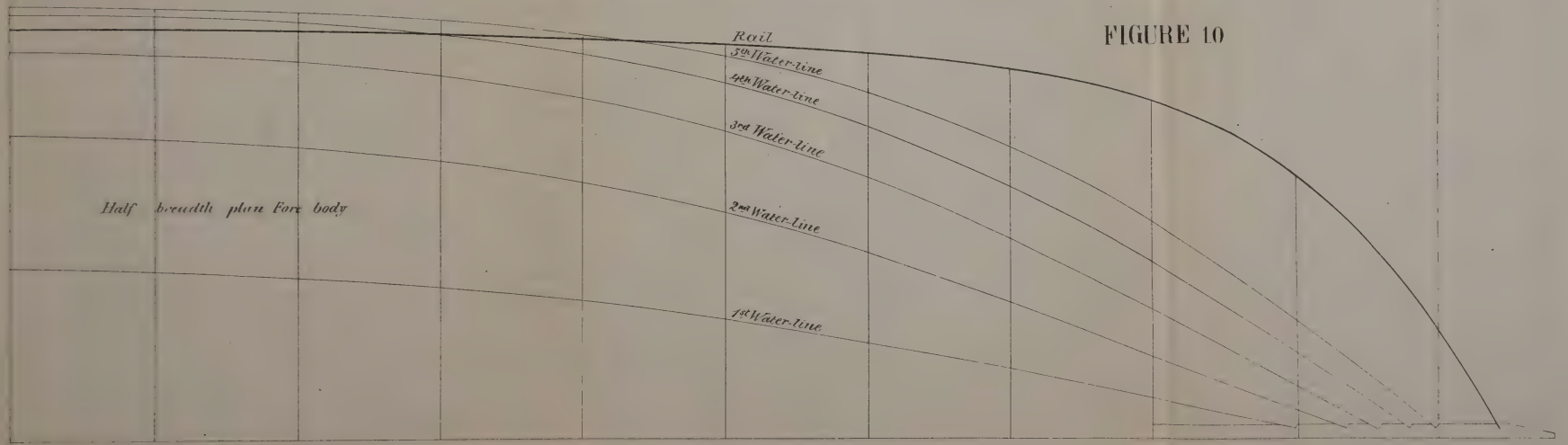


FIGURE 10



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measured off the spaces from the lines 50 E., (Fig. 6,) 65 E., (Fig. 7,) and 80 E., (Fig. 8.,) and transferred all those measurements to their corresponding horizontal lines in the body plan, (Fig. 4,) making spots at each point so set off, curved lines drawn through the spots of each separate section will represent the shape of the several transverse sections, at each division of the ship, namely, ten divisions forward and ten divisions aft.

Now to represent the horizontal planes of the several water-lines, (see Fig. 10,) proceed as follows: Determine upon the length of the ship, and draw a base-line, then erect a perpendicular at the forward end of the line, and set off the position of ⊠, which may be in this case two fifths of the whole length abaft the forward perpendicular; then erect ten perpendiculars to correspond with the number of sections drawn in the quadrant and body plan, number the sections the same as the arc of the quadrant, (commencing at ⊠,) 1, 2, 3, 4, etc. Then draw a longitudinal section representing a profile of the ship, cutting the middle in the direction of her length, (this is called the sheer plan,) Fig. 9. Then draw another base-line, Fig. 10, below the sheer plan to represent the middle line of the horizontal planes, (called the half-breadth plan,) and draw the perpendicular sections down to this line, and proceed as follows: From the body plan measure off the distance of the sections (⊠ to 9) from the middle line E. F. to where they intersect the fifth W. L. forward, and transfer those measurements to the half-breadth plan, Fig. 10, set them off from the base-line on the sections 1, 2, 3, etc., and make a spot at each point so set off, and a curve line drawn through those points will represent the shape of the horizontal plane of the fifth or load water-line forward. The height of the horizontal lines being set off in the sheer plan, the point where those lines inter-

sect the stem may be squared down to the half-breadth plane which will show their endings on this plan. In the same manner may be represented the shape of all the horizontal planes or water-lines below the load-line.

The after part of the ship is measured from the sections represented in the after-body plan, and the shapes of the horizontal sections aft may be represented in the same manner as above described in the fore-body. See Figs. 11 and 12.

The accompanying draught (refer to draught No. 1) exhibits a variety of shapes drawn from the diagram represented by Fig. 3; the curve-lines, Fig. 5, are all obtained in the manner heretofore described, and may be measured off from the scale, Fig. 4, and will be found to agree with the quadrant and tables A. and B., if the first lines are drawn to their respective points in the quadrant, as shown on Fig. 3 to 8.

The table, C., is varied from the combination selected, in order to show that we are not limited by that table. It will be perceived that the horizontal lines selected for Fig. 8 are the same as Fig. 11, and that the numbers selected for Fig. 6 are the same as Fig. 10, but that the section at ⊠ is changed in each case, thereby making different forms. Fig. 13 shows the lines for a commercial steamer, which may be varied at pleasure, as shown by the dotted lines on Figs. 12 and 13.

It may be necessary to show more fully the method of constructing by the scale, after the proportional diminish of the several lines is tabulated. We will therefore refer to the scale, Fig. 15.

The scale of equal parts will be found useful in constructing a ship's draught from the tables hereafter described as follows:

First. Determine upon the half-breadth of beam, which

FIGURE 11

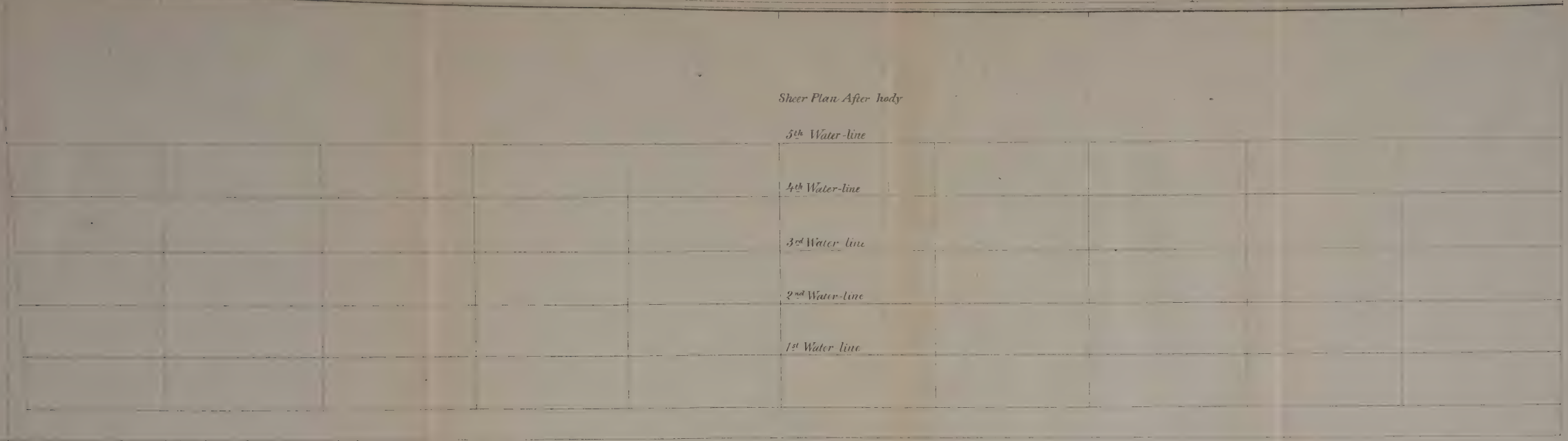
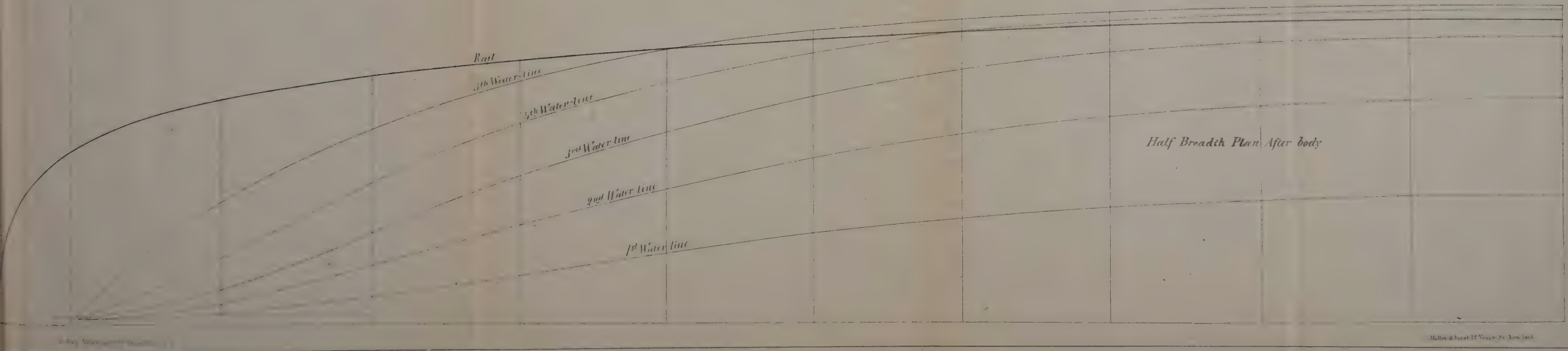


FIGURE 12.



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may be represented by the upper line on the scale marked 0, 1, 2, 3, etc. Then, having drawn in the shape of the greatest transverse section (marked ⊠) and also the level of the fifth or load water-line, the points where the transverse sections cut this line on the body plan may be also set off from the same scale, but the intermediate water-lines are measured off by the reduced scales below, made to conform to the unit of breadth of each water-line.

If the shape of the lines selected from the table of combination of numbers when set off in the body plan on their corresponding water-lines produce fair transverse sections, the draught may be said to be proved. But if the points set off require to be altered, it may be done by changing the numbers above or below those selected, as they may require to be made fuller or sharper, agreeably to the shape of ⊠, as it may be changed from one number to another, and the same column of lines selected for different midship frames.

TABLE OF HORIZONTAL SECTIONS.

Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14
⊠	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	..	..	1.0000	.9998	.9997	.9996	.9995	.9994	.9993	.9992	.9991	.9990	.9989	.9988
2	..	..	.9990	.9986	.9984	.9982	.9980	.9978	.9974	.9970	.9962	.9960	.9952	.9950
3	..	..	.9975	.9968	.9952	.9938	.9930	.9915	.9905	.9890	.9876	.9860	.9855	.9840
4	..	..	.9925	.9885	.9870	.9838	.9815	.9790	.9762	.9740	.9712	.9688	.9655	.9630
5	..	..	.9840	.9785	.9730	.9685	.9620	.9580	.9525	.9476	.9425	.9375	.9330	.9280
6	..	..	9708	.9610	.9510	.9412	.9325	.9230	.9130	.9060	.8980	.8900	.8820	.8750
7	..	..	.9460	.9300	.9126	.8930	.8805	.8677	.8520	.8400	.8260	.8150	.8020	.7910
8	..	..	.9075	.8725	.8440	.8170	.7920	.7710	.7516	.7325	.7080	.6920	.6720	.6520
9	..	..	.7900	.7325	.6878	.6460	.6014	.5720	.5378	.5130	.4860	.4640	.4410	.4200
Sum	..	..	.9582	.9458	.9318	.9241	.9140	.9059	.8966	.8903	.8814	.8746	.8675	.8611
Dec.	..	..	.9082	.8958	.8818	.8741	.8640	.8559	.8466	.8403	.8314	.8246	.8175	.8111

TABLE OF HORIZONTAL SECTIONS.

Section	16	18	20	22	24	26	28	30	32	34	36	38	40	42
⊗	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	.9982	.9981	.9980	.9979	.9978	.9977	.9976	.9975	.9974	.9973	.9972	.9971	.9970	.9969
2	.9945	.9945	.9930	.9925	.9920	.9910	.9900	9880	.9875	.9875	.9860	.9850	.9850	.9835
3	.9815	.9800	.9775	.9760	.9730	.9705	.9685	.9660	.9630	.9620	.9585	.9575	.9550	.9520
4	.9580	.9545	.9500	.9440	.9400	.9340	.9290	.9250	.9200	.9155	.9105	.9070	.9025	.8976
5	.9185	.9105	.9020	.8940	.8860	.8770	.8680	.8610	.8520	.8450	.8375	.8305	.8230	.8155
6	.8585	.8450	.8320	.8180	.8050	.7920	.7800	.7675	.7555	.7450	.7350	.7235	.7150	.7040
7	.7650	.7455	.7240	.7060	.6880	.6700	.6340	.6385	.6225	.6090	.5960	.5825	.5700	.5575
8	.6225	.5960	.5680	.5450	.5220	.5005	.4810	.4625	.4460	.4305	.4145	.4010	.3875	.3750
9	.3810	.3505	.3220	.3000	.2775	.2560	.2380	.2225	.2075	.1960	.1825	.1712	.1600	.1500
Sum	.8467	.8374	.8276	.8173	.8081	.7968	.7916	.7828	.7753	.7687	.7617	.7555	.7475	.7332
Dec.	.7967	.7874	.7776	.7673	.7581	.7468	.7416	.7328	.7253	.7187	.7117	.7055	.6975	.6832

TABLE OF HORIZONTAL SECTIONS.

Section	44	46	48	50	55	60	65	70	75	80	85	90	95	100
⊠	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	.9968	.9967	.9966	.9960	.9956	.9953	.9950	.9940	.9930	.9925	.9923	.9915	.9905	.9900
2	.9825	.9820	.9810	.9800	.9775	.9748	.9720	.9690	.9660	.9635	.9605	.9580	.9550	.9520
3	.9505	.9475	.9448	.9425	.9360	.9300	.9240	.9177	.9120	.9060	.9005	.8940	.8875	.8815
4	.8935	.8885	.8858	.8800	.8700	.8580	.8475	.8375	.8275	.8175	.8075	.7985	.7876	.7785
5	.8090	.8025	.7958	.7890	.7726	.7570	.7420	.7275	.7127	.7000	.6875	.6750	.6620	.6505
6	.6960	.6870	.6760	.6675	.6460	.6260	.6075	.5910	.5728	.5575	.5425	.5274	.5125	.5010
7	.5455	.5350	.5240	.5125	.4890	.4675	.4460	.4275	.4090	.3940	.3775	.3625	.3480	.3360
8	.3625	.3510	.3400	.3290	.3052	.2835	.2650	.2470	.2310	.2160	.2025	.1900	.1785	.1670
9	.1400	.1310	.1230	.1150	.0990	.0825	.0690	.0570	.0450	.0350	.0250	.0160	.0075	.0000
Sum	.7376	.7331	.7266	.7210	.7090	.6974	.6868	.6767	.6670	.6582	.6495	.6412	.6329	.6256
Dec.	.6876	.6831	.6766	.6710	.6590	.6474	.6368	.6267	.6170	.6082	.5995	.5912	.5829	.5756

TABLE OF TRANSVERSE SECTIONS.

Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14
5th W. L.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	.9999	.9998	.9997	.9996	.9995	.9994	.9993	.9992	.9991	.9990
2	1.0000	1.0000	.9990	.9988	.9986	.9984	.9982	.9980	.9978	.9976	.9974	.9970	.9965	.9960
3	.9990	.9980	.9975	.9965	.9955	.9945	.9935	.9925	.9915	.9910	.9890	.9880	.9870	.9860
4	.9980	.9955	.9925	.9900	.9878	.9840	.9820	.9800	.9770	.9752	.9725	.9705	.9680	.9660
5	.9950	.9405	.9840	.9790	.9740	.9690	.9630	.9586	.9540	.9510	.9450	.9410	.9360	.9327
6	.9900	.9810	.9710	.9620	.9525	.9426	.9335	.9255	.9160	.9110	.9025	.8955	.8875	.8815
7	.9820	.9640	.9462	.9320	.9150	.9010	.8838	.8720	.8570	.8460	.8340	.8235	.8110	.8012
8	.9662	.9340	.9040	.8775	.8490	.8235	.7990	.7800	.7580	.7415	.7225	.7075	.6912	.6775
9	.9225	.8575	.7990	.7450	.7012	.6620	.6240	.5960	.5660	.5420	.5175	.5000	.4980	.4605
Sum	.9852	.9720	.9603	.9479	.9373	.9274	.9176	.9102	.9017	.8954	.8879	.8822	.8754	.8700
Dec. of	⊠		.9103	.8979	.8873	.8774	.8676	.8602	.8517	.8454	.8379	.8322	.8254	.8200

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TABLE OF TRANSVERSE SECTIONS.

Section	16	18	20	22	24	26	28	30	32	34	36	38	40	42
5th W. L.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	.9989	.9988	.9987	.9986	.9985	.9984	.9983	.9982	.9981	.9980	.9979	.9978	.9977	.9976
2	.9955	.9950	.9945	.9940	.9930	.9925	.9920	.9910	.9900	.9900	.9885	.9885	.9875	.9875
3	.9835	.9820	.9810	.9780	.9760	.9740	.9725	.9705	.9680	.9670	.9650	.9630	.9620	.9600
4	.9612	.9575	.9526	.9485	.9445	.9408	.9360	.9330	.9285	.9253	.9210	.9180	.9150	.9112
5	.9235	.9160	.9080	.9020	.8950	.8875	.8800	.8740	.8675	.8610	.8550	.8500	.8440	.8378
6	.8660	.8540	.8425	.8305	.8190	.8078	.7980	.7880	.7780	.7700	.7615	.7526	.7452	.7375
7	.7800	.7605	.7425	.7270	.7105	.6960	.6825	.6700	.6570	.6455	.6340	.6235	.6135	.6050
8	.6470	.6220	.5990	.5800	.5580	.5405	.5240	.5100	.4960	.4835	.4710	.4600	4500	.4400
9	.4275	.4008	.3760	.3580	.3380	.3210	.3070	.2960	.2820	.2725	.2625	.2540	.2450	.2380
Sum	.8583	.8486	.8394	.8316	.8232	.8158	.8090	.8030	.7965	.7912	.7856	.7807	.7749	.7714
Dec. of ⊠	.8088	.7986	.7894	.7816	.7732	.7658	.7590	.7530	.7465	.7412	.7356	.7307	.7249	.7214

TABLE OF TRANSVERSE SECTIONS.

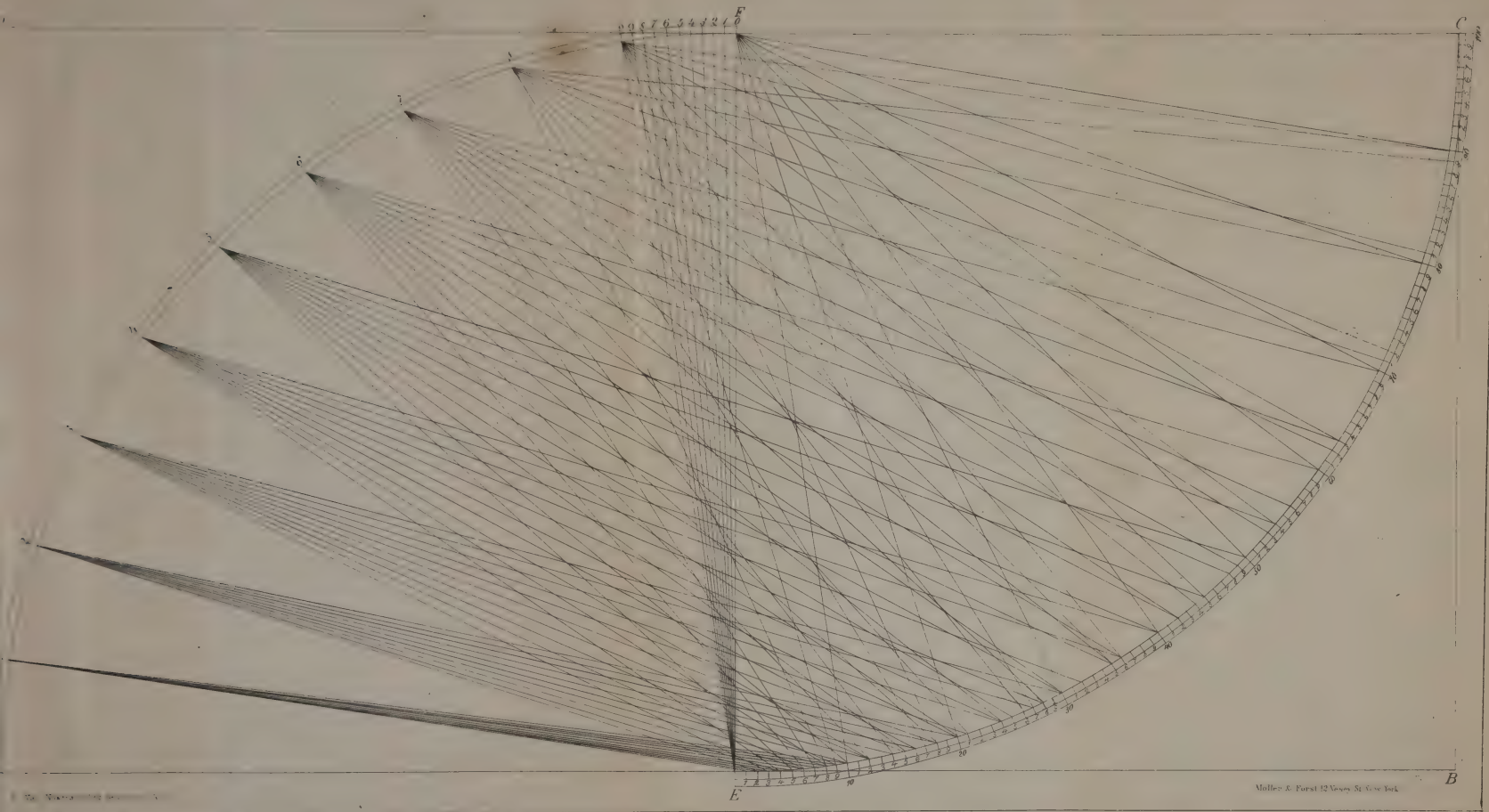
Section	44	46	48	50	55	60	65	70	75	80	85	90	95	100
5th W.L.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	.9975	.9974	.9973	.9972	.9971	.9970	.9969	.9968	.9967	.9966	.9964	.9963	.9960	.9958
2	.9870	.9860	.9850	.9850	.9830	.9920	.9805	.9790	.9780	.9770	.9750	.9740	.9725	.9715
3	.9585	.9570	.9550	.9545	.9500	.9452	.9420	.9380	.9350	.9315	.9285	.9280	.9228	.9205
4	.9080	.9050	.9020	.8990	.8925	.8850	.8785	.8720	.8670	.8610	.8550	.8510	.8455	.8420
5	.8330	.8275	.8225	.8180	.8075	.7975	.7875	.7780	.7705	.7625	.7550	.7485	.7426	.7375
6	.7305	.7230	.7160	.7100	.6970	.6825	.6700	.6580	.6490	.6400	.6320	.6245	.6175	.6125
7	.5970	.5885	.5805	.5725	.5550	.5400	.5270	.5150	.5050	.4960	.4880	.4810	.4750	.4700
8	.4312	.4230	.4140	.4060	.3910	.3765	.3640	.3530	.3440	.3370	.3300	.3240	.3200	.3160
9	.2325	.2250	.2200	.2150	.2030	.1950	.1855	.1800	.1735	.1700	.1650	.1625	.1600	.1575
Sum	.7675	.7632	.7592	.7557	.7476	.7400	.7331	.7269	.7213	.7771	.7184	.7087	.7051	.7023
Dec. of ⊠	.7175	.7132	.7092	.7057	.6976	.6900	.6831	.6769	.6713	.6671	.6654	.6587	.6551	.6523

Fig. 13 represents a diagram by which the proportionate diminish of each line may be measured off by a scale of equal parts and tabulated for ready reference, so that, when a set of numbers are selected from the table of combination of numbers, the draught of any ship may be constructed by a scale of equal parts, by reference to the table instead of the diagram; this will be found convenient in draughting and making calculations upon the capacity, stability, etc., of the draught about being constructed, as the value of each line may be known at a glance.

This diagram is drawn in similar to Fig. 1, omitting the lines drawn from the arc A. F. and C. E. to E., as they are not required in this case. A first line may be drawn from F. to any of the numbers on the arc E. C. to 10, to 20, to 90, and so on in each case; dividing the space from the point on the arc of the quadrant to which the dividing line is drawn, into equal parts corresponding with the arc A. F., and the lines being drawn from the sections on that arc to the several divisions, the distance is measured off by a scale of decimal parts, (radius being unit,) from where they intersect the line E. F. to the arc A. F.; set down the results in tabular columns of decimals, and the place to which the first line is drawn, from F. to the arc of the quadrant E. C., gives the name of the curve-line represented in the table, and showing the proportional diminish of each line formed by the division from 1 to 100; thus forming a scale of curve-lines suitable for the greatest transverse sections of different vessels, as may be required, selecting such as are best adapted to the purpose for which the ship is designed. (The scale of curve-lines may be seen by reference to draught No. 1.)

Now, the divisions being ten in number, and the decimals being placed in columns, the sum of each column

FIGURE 13



pointed off as a decimal less .0500, (or one half of unit,) will approximate to its decimal nearly in proportion to a circumscribing parallelogram. Thus we shall have 100 shapes suitable for ⊠, or the greatest transverse sections.

The horizontal lines of the ship are measured off from the quadrant in the same manner as the transverse sections, with this difference; as it becomes necessary to shorten the lower lines as they approach the keel, the middle line from which the measurements are taken is gradually inclined toward section 9 on the quadrant, until the dividing number is 100, when it intersects 9, and terminates that line. Therefore let the space from the perpendicular to 9 on the arc of the quadrant be divided into ten equal parts to correspond with the sections set off on the quadrant, and for each measurement make a new line from which to measure the distances to the arc of the left-hand quadrant, (A. F.)

Now, from the measurements taken off from the arc of the quadrant, as above described, to the line representing the middle line, a table may be made representing the proportional diminish or narrowing of each line suitable for the horizontal lines of a ship, and its decimal in proportion to a circumscribing parallelogram, each line being known by its number from 1 to 100. The form of the lines produced may now be compared with vessels of known good qualities, in the manner heretofore described; and the shape of any vessel represented by the corresponding numbers, or those which approximate to the lines produced from the quadrant, and from those comparisons a combination of numbers are formed which will produce suitable lines to form the bottom or immersed part of vessels of all descriptions. Now, the mean decimal of the combination of a set of lines selected for the horizontal lines multiplied by the mean deci-

mal of breadth of the midship section, produces the decimal in proportion to a circumscribing paralleopipedon nearly.

To illustrate the method of delineating a draught from the tables, as well as to show how the form may be changed, by adopting different midship sections for the same column of numbers, we will take the same column, (No. 11,) that has been taken for the sloop-of-war, and by adopting a different midship form, produce quite a different ship. (See Fig. 14.) Now let the midship frame be No. 4, instead of No. 50, but the water-lines as before, namely,

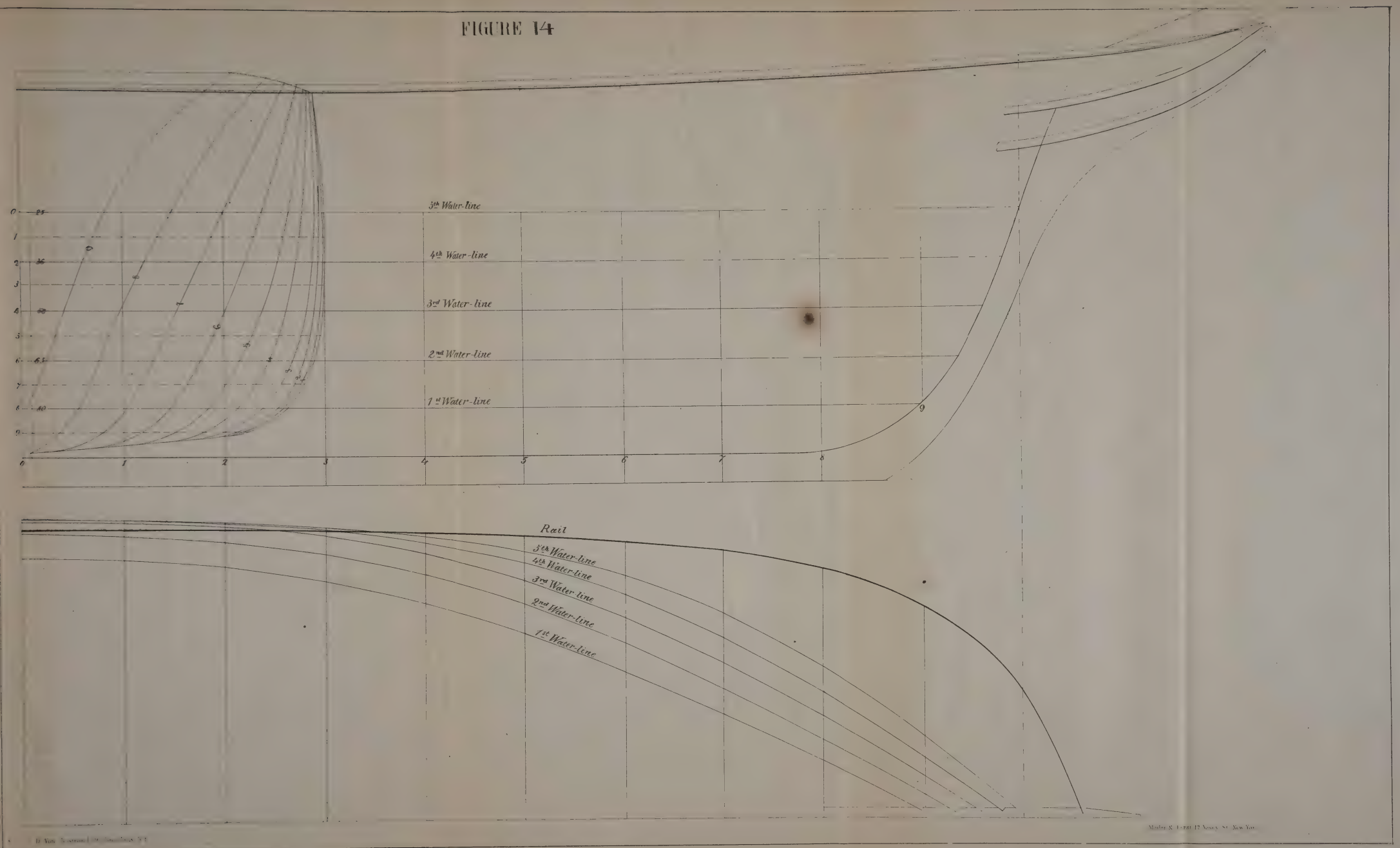
5th	W. L.	forward	26
4th	"	"	36
3d	"	"	50
2d	"	"	65
1st	"	"	80

Then from the tables on page 25, Transverse Sections, under No. 4, is found its shape; and under 26, 36, 50, 65, and 80, on pages 23 and 24, Horizontal Sections, will be found the shape and proportional diminish of each water-line as follows:

	⊠ 4	5th W. L. 26	4th W. L. 36	3d W. L. 50	2d W. L. 65	1st W. L. 80
1st Section,	1.0000	.9977	.9972	.9960	.9950	.9925
2d Section,	.9988	.9910	.9860	.9800	.9720	.9635
3d Section,	.9965	.9705	.9585	9425	.9240	.9060
4th Section,	.9900	.9340	.9105	.8800	.8475	.8175
5th Section,	.9790	.8770	.8375	.7890	.7420	.7000
6th Section,	.9620	.7920	.7350	.6675	.6075	.5575
7th Section,	.9320	.6700	.5960	.5125	.4460	.3940
8th Section,	.8775	.5005	.4145	.3290	.2650	.2160
9th Section,	.7450	.2560	.1825	.1150	.0690	.0350

First construct the midship frame to any breadth represented on the scale, by setting off on the several horizontal

FIGURE 14


5th Water-line
4th Water-line
3rd Water-line
2nd Water-line
1st Water-line
0
1
2
3
4
5
6
7
8
9
Rail
5th Water-line
4th Water-line
3rd Water-line
2nd Water-line
1st Water-line

lines the diminish below the load water-line, and then, from the intersection of the several water-lines with ⊠, take off the breadth at those points, and transfer them to the scale of equal parts, and draw a line where each breadth intersects the line O and 10, so that each water-line may be divided into 100 parts at its greatest breadth. Then, by the scales thus obtained, may be drawn in all the intersections of the several transverse sections with the horizontal lines on the body plan set off from the tables; and lines drawn through these intersections, represent the shape of the transverse sections in the fore body changed from shape shown on Fig. 4, (where ⊠ is 50,) to conform to shape of new midship section, (No. 4.)

Note.—In constructing the draught from the quadrant, the transverse sections at 9 may be varied to suit such shape of stem and rake of post, as may be adopted in the sheer plan, but no variation should be allowed on the remaining sections; all other sections should conform to the proportional diminish produced from the quadrant.

It may be well to observe, that, in selecting the proper numbers from the tables of proportional diminish of the horizontal lines, after having drawn the shape of the midship section, and made the scales for each water-line where the horizontal lines intersect ⊠, to try the shape of section 7, which should be nearly a straight line from the keel to the load water-line, to produce a good after-body, and, after having determined upon the shape of this section, the numbers of the curves from which it is drawn may be relied upon to produce the proper curves for the remaining sections.

In like manner try the shape of section 8 in the fore-body, which should also be nearly straight from the keel to the fifth or load water-line, and if the numbers selected from the table produce the desired shape, the fore-body

is correct, and the remaining sections may be relied upon to produce a fair and handsome fore-body.

Having compared the curves produced from the diagram as above described, with a large number of good vessels of different descriptions, the following table is selected as a suitable combination of numbers for vessels of all descriptions.

				74-gun Ships or 1st Class Frigates.		2d Class Frigates and Sloops-of-War.		Sloops and Brigs-of-War.		Cutters and War-Steamers.		Commercial Steamers.			
Numbers,	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Abaft ⊠, 5th Water-Line, Before ⊠,	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30
	8	10	12	14	16	18	21	24	27	30	35	40	45	50	55	60	65	70
Abaft ⊠, 4th Water-Line, Before ⊠,	11	12	13	14	16	18	20	22	24	26	30	34	38	42	46	50	55	60
	12	14	16	18	20	22	25	30	35	40	45	50	55	60	65	70	75	80
Abaft ⊠, 3d Water-Line, Before ⊠,	16	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80
	16	20	26	28	32	36	40	45	50	55	60	65	70	75	80	90	100	100
Abaft ⊠, 2d Water-Line, Before ⊠,	25	30	35	40	45	50	60	70	80	90	100	100	100	100	100	100	100	100
	25	30	35	40	45	50	60	70	80	90	100	100	100	100	100	100	100	100
Abaft ⊠, 1st Water-Line, Before ⊠,	45	48	52	56	60	64	68	72	76	80	85	90	95	100	100	100	100	100
	45	48	52	56	60	64	68	72	76	80	85	90	95	100	100	100	100	100
	Cotton Ships.			Freighting Ships.		Indiamen		and Packets.		Clipper-Ships.								

Note, 1854.—The diagonal lines will be the best for first-class war-propeller, 50 guns, 275 long, 55 beam, ⊠=8.

Note.—No. 10 perpendicular column, has proved so far to be the very best clipper-ship, 1854, ⊠=16.

The numbers for ships of war may be taken off from this table in the diagonal direction from 18 to 30 to 38 to 30, etc., because it is proper to construct those ships fuller forward in proportion to the after-body, to sustain the necessary equipment conveniently arranged.

Other vessels may be taken off from the columns in the perpendicular direction from top to bottom as their cargo may be more equally distributed; but, if desirable, they may be taken off diagonally, as from 20 to 45 to 38 to 55, etc., which would make both ends nearly equal, and the ship would be balanced in the middle of her length. By the above arrangement, the midship-frame is placed two fifths of the length between perpendiculars abaft the forward perpendicular, and the height of the fifth or load water-line two fifths of breadth above base-line. The ship is supposed to be two thirds of the depth from base to plankshire immersed when brought down to the load-line. The length of sailing ships may be from four to five times the breadth, and for sea-steamers, six times the breadth.

Propellers should be about five times the breadth for the length. By comparison I find but one sloop-of-war built very nearly by the numbers represented by the diagonal lines from 12 to 30 to 18 to 42 to 30 to 55 to 60 to 80 to 64 to 80, while nearly all others follow the numbers in the direction of the diagonal line from 18 to 20 to 38 to 32 to 60 to 45 to 75 to 60 to 95 to 80.

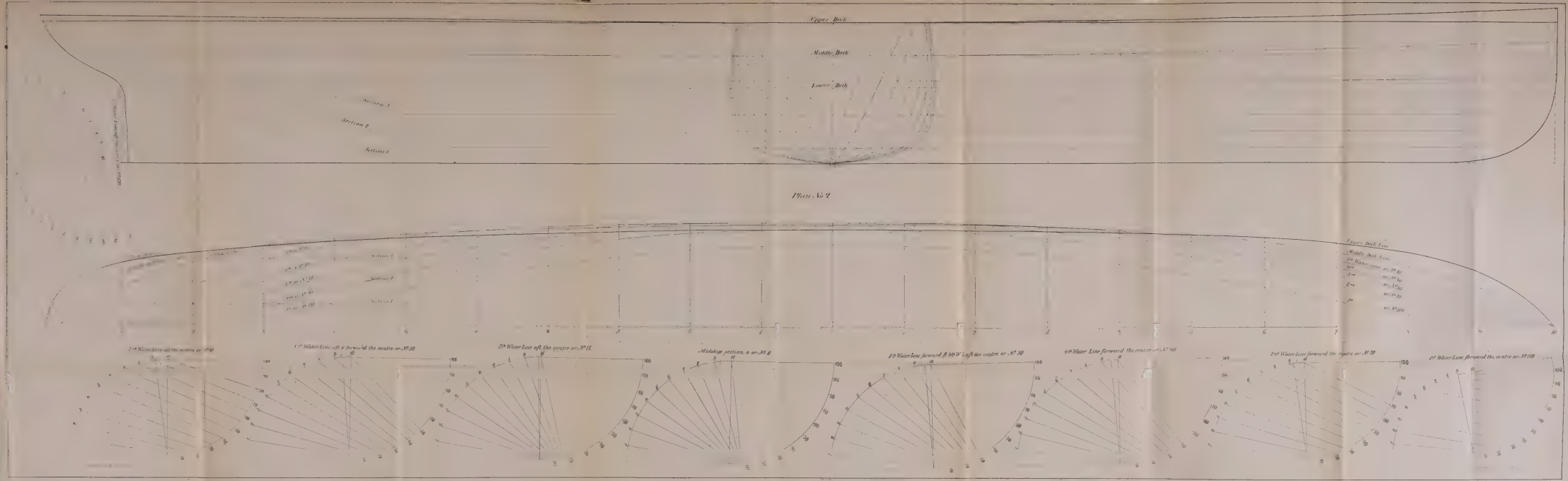
It seems then (by comparison) that there is a great difference of opinion in relation to the position of the centre

of cavity of the body immersed; that while some ships have been built with the centre of cavity in the middle, others have been built with the centre of cavity from one to five feet before the middle.

But if some such plain and simple system as that which I have endeavored to explain, were adopted for delineating and comparing the forms of ships; and ships constructed by this method, compared with other ships, when they are as nearly as possible under the same circumstances in practice; standard rules might be fixed for the best forms of ships hereafter to be built.

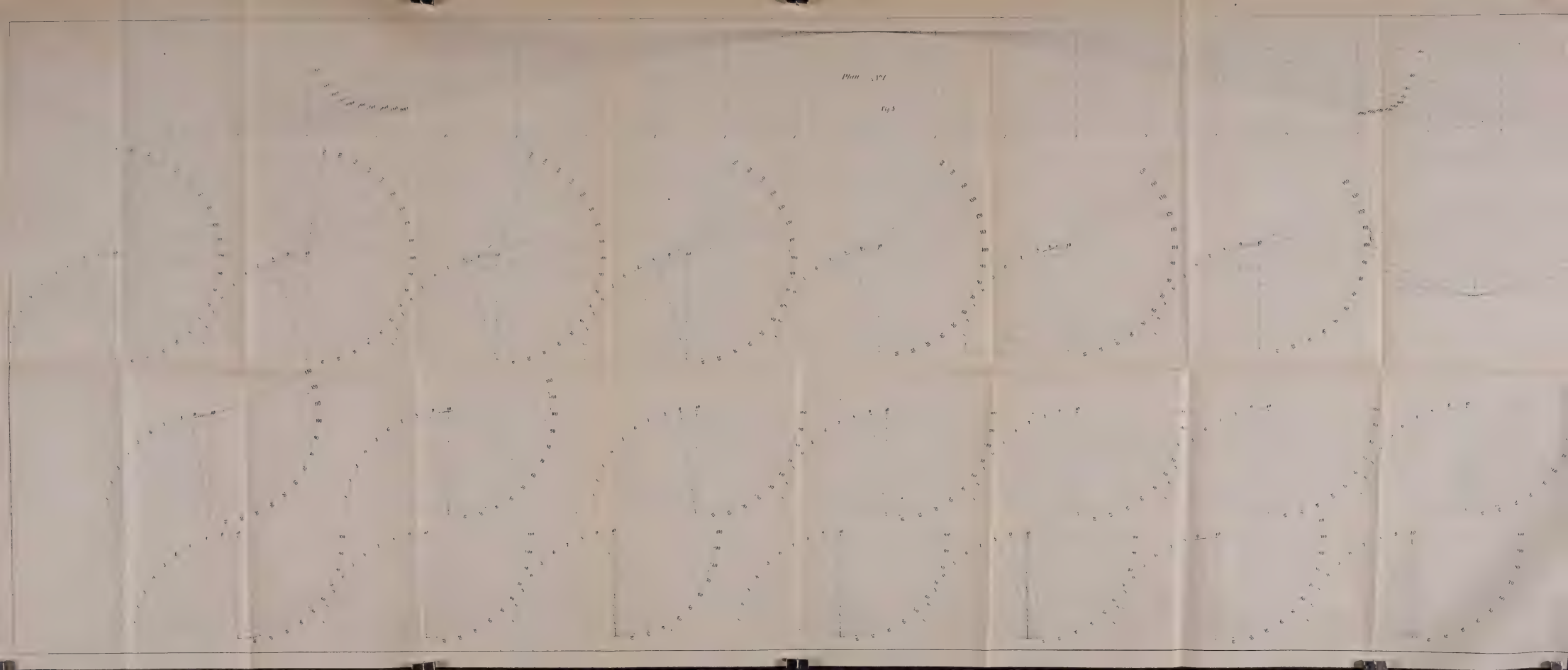
Plan No. 1

shows the method of obtaining the shape of all the lines that may be required to form a vessel of any required capacity. There are twenty diagrams representing as many water-lines. It will be seen, by inspecting the diagrams, that the points to which the line is drawn from 10 in the perpendicular lines to any number on the right-hand segment of a circle designates the number of the line, and the space from that number to the perpendicular line is divided into ten equal parts corresponding with the divisions on the left-hand quadrant from which the lines are drawn intersecting the perpendicular line to each corresponding division on the right-hand segments. The space between the perpendicular line and 9 on the left-hand quadrant is divided into ten equal parts, and when the number of the line required is selected as stated above, a line is drawn from a corresponding number on the left-hand quadrant to where the perpendicular intersects the base-line; and where this last-named line intersects the ten divisions, the measurements are taken off and set off on the perpendicular lines on their corresponding numbers, which represent the horizontal shape of


Upper Deck
Middle Deck
Lower Deck
Section 1
Section 2
Section 3
Plate No 2
Upper Deck Line
Middle Deck Line
1st Water Line above the centre or. N°10
1st Water Line aft & forward the centre or. N°10
5th Water Line aft the centre or. N°15
Midship section. a or. N° 8
2d Water Line forward & 4th W Line aft the centre or. N° 30
4th Water Line forward the centre or. N° 60
2nd Water Line forward the centre or. N° 70
1st Water Line forward the centre or. N° 110

Plan. N°1

Fig 3



the lines, called water-lines,* as may be seen by inspecting the plan of water-lines above the diagrams. The area of all these lines is then carefully measured, and the proportion which they bear to a circumscribing parallelo gram is inserted in the tables opposite their numbers, from which a vessel of any required capacity or form may be selected. The shape of the midship frame is obtained in the same manner, except that the measurements are in all cases taken off from where the perpendicular line intersects the ten divisions before described, in lieu of being taken from the inclined lines.

Plan No. 2

is made from the tables, and is taken from the ninth column, being a mean of the table of the combination of numbers; and it will show how a plan is made from the tables after the numbers have been selected. By reference to the tables, it will be seen that the numbers represented in the ninth column are for the load-line 15 aft and 30 forward; for the fourth water-line, 30 aft and 40 forward; for the third water-line, 50 aft and 50 forward; for the second water-line, 80 aft and 70 forward; and for the first water-line, 120 aft and 110 forward. The midship-frame selected is No. 8. After the diagrams of the above numbers have been drawn in as before described, the measurements are taken off, and the water-lines are drawn into the half-breadth plan as represented; then from the water-lines may be taken off the shape of the transverse sections as represented in the body-plan, showing their shapes from the base-line up to the load water-line; and thereby is obtained the shape of the immersed part of

* The termination of the lines may be modified to suit the shape of the rabbets of the stem and stern, by giving them a fair outward curve from section 7 to the rabbets, forming what is called a hollow water-line at the extremity.

the vessel both horizontally and transversely from keel to load water-line. The top of the vessel, or all above the water, may then be drawn to suit the fancy of the designer, or to suit the object for which the vessel is intended. The frames representing the fore-body of the vessel may be run up fair to the rail or upper deck, and then a line may be selected from a diagram to suit the shape of the required line from the stem to the sixth section abaft ⊠ at this height. The rake of the counter being determined upon, this line will then be continued aft, making a fair line to its termination, and then any intermediate lines that may be required can be obtained by running in longitudinal or horizontal section, as shown in the plan. To complete the plan the frames may now be drawn in at a proper distance apart, the position of the decks drawn in on the sheer plan, and their shapes taken off from the body-plan, and the internal arrangements drawn in.

The lines selected from the table and from which this plan is drawn, are deduced from a comparison of the best and most approved models of ships that have been built.

To give a proportion to the scantling of the several parts of the vessel, I generally adopt the following rule, as approximating to the proper dimensions of stuff, namely, Multiply the breadth of beam in feet by the following decimals for the size in inches :

For siding of keel by... .42, cable-bitts, ... .45
" " frame by.... .28, cat-heads,..... .40
Moulded at floor-head by .28, stanchions in hold, .20
" at planksheer by .14, coaming of hatches, .17
Throat by.... .42, clamps and wales, .15
Beams from..... .35 to. 38, thick stuff,..... .20
Deck plank,..... .10, knees sided,..... .22
Bottom do., ... .10, room and space, .70 to .75
Carlines, .22, ledges,.... .15.

To obtain the cubical contents of any vessel, multiply the decimal in the foregoing tables, opposite ⊕, which represents the greatest transverse section, by the product of the length, breadth, and depth of the vessel regarded as a parallelopipedon, and the result will be the contents, in cubic feet, of the immersed part of the vessel, which, divided by 35, will give the number of tons (of 2240 lbs.) displacement, salt water being regarded as equal to 64 lbs. to the cubic foot. It will thus be seen that the lines for a vessel of any required capacity can be selected from the tables.

EXAMPLE.—If we take column No. 2 and ⊕ 3=.726, the vessel being 250 feet long, 40 feet beam, and immersed 16 feet exclusive of the keel, then 250×40×16=160,000 cubic feet×.726=116,160÷35= 3318$\frac{6}{7}$ tons.
But if ⊕ 25 be taken, 160,000 ft. ×.97,280÷35= 2779$\frac{3}{7}$ "
Making a difference of 539$\frac{3}{7}$ "
or about one sixth, by changing the midship section on the same lines.

Again, if column No. 6 ⊕ 3 = .654 then 160,000 feet ×.654=104,640 ft. ÷ 35 = 2989$\frac{5}{7}$ tons,
but if ⊕ 25 be taken, 160,000 ft. × .551 =
88,160 ÷ 35 = 2518$\frac{6}{7}$ "
Making a difference of 470$\frac{6}{7}$ "

It will thus be seen that by modifying the midship section, although the same form of water-lines be taken, a great difference will be made in the capacity of the ship. Therefore we can choose the shape of the fore and aft lines in any of the above columns from 1 to 6, and adapt a midship frame to suit any required capacity.

Table showing the Decimal of each Line, from Nos. 1 to 100, either as a Midship Section or Water-Line, and showing those lines which will balance each other before and abaft the middle of the length of the Ship, from the base to the load water-line, being divided into ten equal parts.

	3	4	5	6	7	8	9	10	11	12	13	14	16	18	20	22	24	
	.790	.732	.687	.646	.601	.572	.537	.513	.486	.464	.441	.420	.381	.350	.322	.300	.277	W. L.
9	.799	.745	.702	.662	.624	.596	.566	.542	.517	.500	.498	.460	.429	.400	.376	.358	.338	⊕
	.902	.872	.844	.817	.792	.771	.747	.737	.708	.692	.672	.657	.622	.596	.568	.545	.522	W. L.
8	.904	.877	.849	.823	.799	.780	.758	.741	.722	.707	.691	.677	.647	.622	.599	.580	.558	⊕
	.946	.930	.912	.893	.880	.867	.852	.840	.826	.815	.802	.791	.765	.745	.724	.706	.688	W. L.
7	.948	.932	.915	.901	.883	.872	.857	.846	.834	.823	.811	.801	.780	.760	.742	.727	.710	⊕
	.970	.961	.951	.941	.932	.923	.913	.906	.898	.890	.882	.875	.858	.845	.832	.818	.805	W. E.
6	.971	.962	.952	.942	.933	.925	.916	.901	.902	.895	.887	.881	.866	.854	.842	.830	.819	⊕
	.984	.978	.973	.968	.962	.958	.952	.974	.942	.937	.933	.928	.918	.910	.902	.894	.886	W. L.
5	.985	.979	.974	.969	.963	.959	.954	.951	.945	.941	.936	.932	.923	.916	.908	.902	.895	⊕
	.992	.988	.987	.983	.986	.979	.976	.974	.971	.968	.965	.963	.958	.954	.950	.944	.940	W. L.
4	.993	.990	.988	.984	.982	.980	.977	.975	.972	.970	.968	.966	.961	.957	.952	.948	.944	⊕
	.997	.996	.995	.993	.992	.991	.990	.989	.987	.984	.985	.984	.981	.980	.977	.976	.973	W. L.
3	.998	.997	.996	.994	.993	.992	.991	.991	.989	.988	.987	.986	.983	.982	.981	.978	.996	⊕ W. L.
2	.999	.998	.998	.998	.997	.997	.997	.997	.997	.997	.996	.995	.994	.993	.992	.991	.990	⊕ W. L.
1	.100	.100	.999	.999	.999	.999	.999	.999	.999	.999	.999	.999	.999	.999	.999	.999	.999	⊕

	26	30	34	38	42	46	50	55	60	65	70	75	80	85	90	95	100	
	.256	.222	.196	.171	.150	.131	.115	.099	.082	.069	.057	.045	.035	.025	.016	.007	.000	W. L.
9	.231	.296	.272	.254	.238	.225	.215	.203	.195	.185	.180	.173	.170	.165	.162	.160	.157	⊕
	.500	.462	.430	.401	.375	.351	.329	.305	.283	.265	.247	.321	.216	.202	.170	.178	.167	W. L
8	.540	.510	.483	.460	.440	.423	.406	.391	.376	.364	.353	.344	.337	.330	.324	.320	.316	⊕
	.670	.638	.609	.582	.557	.535	.512	.489	.467	.446	.427	.409	.394	.377	.362	.348	.336	W. L.
7	.696	.670	.645	.623	.605	.588	.572	.555	.540	.527	.515	.505	.496	.488	.481	.475	.470	⊕
	.792	.767	.745	.723	.704	.687	.667	.646	.626	.607	.591	.572	.557	.542	.527	.512	.501	W. L.
6	.807	.788	.770	.752	.737	.723	.710	.697	.682	.670	.658	.647	.640	.632	.624	.617	.612	⊕
	.827	.861	.845	.830	.815	.802	.789	.772	.757	.742	.727	.712	.700	.687	.675	.662	.650	W. L.
5	.887	.874	.861	.850	.837	.827	.818	.807	.797	.787	.778	.770	.762	.755	.748	.742	.737	⊕
	.934	.925	.915	.907	.897	.888	.880	.870	.858	.847	.837	.827	.817	.807	.798	.787	.778	W. L.
4	.964	.933	.925	.918	.911	.905	.899	.892	.885	.878	.872	.867	.861	.855	.851	.845	.842	⊕
	.970	.966	.962	.957	.952	.947	.942	.936	.930	.924	.917	.912	.906	.900	.894	.887	.881	W. L.
3	.971	.970	.967	.963	960	.957	.954	.950	.945	.942	.938	.935	.931	.928	.926	.922	.920	⊕
	.991	.988	.987	.985	.983	.982	.980	.977	.974	.972	.969	.966	.968	.960	.958	.955	.952	W. L.
2	.992	.991	.990	.988	.987	.986	.985	.984	.982	.980	.979	.978	.977	.975	.974	.972	.971	⊕
	.997	.997	.997	.997	.996	.996	.996	.995	.995	.995	.994	.993	.992	.991	.990	.989	.988	W. L.
1	.998	.998	.998	.998	.997	.997	.997	.996	.996	.996	.995	.995	.995	.995	.995	.995	.995	⊕

BALANCE FORWARD.

$\frac{2}{5}$	1620.	2224.	26.	2830.	3234.	3638.	4044.	4850.	55.
$\frac{1}{2}$	1516.	1820.	22.	2426.	2830.	3132.	3437.	4044.	48.
$\frac{2}{5}$	55.	60.	65.	70.	75.	80.	90.	100.	
$\frac{1}{2}$	46.	50.	55.	60.	65.	70.	80.	90.	

BALANCE AFT.

$\frac{2}{5}$	1620.	2224.	2628.	3032.	3436.	3840.	4446.	4850.	5560.
$\frac{1}{2}$	1824.	2628.	3032.	3436.	3840.	4246.	4850.	5560.	6570.
$\frac{2}{5}$	60.	65.	70.	75.	80.	85.	90.	95.	100.
$\frac{1}{2}$	70.	75.	80.	85.	90.	95.	100.		

METHOD OF CALCULATING THE CAPACITY AND CENTRE OF GRAVITY BY THE TABLE OF DECIMALS WHEN THE Nos. HAVE BEEN SELECTED.

PROPELLER No. 2, SELECTED AS BEST.

5.	A	16	.7988
	F	20	.7768
4.	A	24	.7579
	F	26	.7492
3.	A	38	.7053
	F	32	.7255
2.	A	60	.6478
	F	42	6931
	A	100	.5782
	F	60	.6478
			70804
⊕=8=			8616

42480
7080
4248
5664

6100128

173644
03

520932
173644

178853 cubic feet.

Note—To make good the loss by calculating the lines straight instead of curve, add .03 × to total amount, after multiplying the water-lines by the distance between them.

Length, exclusive of stem and post at load water-line,..... 266 long.
Outside bottom plk..... 55 wide.

1330
1330

14630
20 deep.

2926.00
.61

2926.00
17556

178486=5890 tons.

W. L.	Length.	Width.	Parallelo-gram.	Decimal.	Area. Cubic feet.	Contents before the Middle.				
10=	133 ×	27.50=	3657 ×	.7988=	2921.21	2840.75	2719.16	2499.34	2226.93	1819.17
8=	133 ×	27.50=	3657 ×	.7579=	2771.64	2719.60	2499.34	2226.93	1819.17	104.00
6=	133 ×	26.50=	3524 ×	.7053=	2485.47	5560.35	5218.94	4726.27	4046.10	1923.17
4=	133 ×	25.50=	3391 ×	.6448=	2196.69	4	4	4	4	4.75
2=	133 ×	21.50=	2857 ×	.5782=	1651.91	22241.40	20875.76	18905.02	16184.40	9135.05
Keel=	133 ×	0.87=	116 ×	. 0=	116.00					
		Fore Body.				Contents abaft the Middle.				
10=	133 ×	27.50=	3657 ×	.7768=	2840.75	2921.21	2771.64	2485.47	2196.69	1651.91
8=	132 ×	27.50=	3630 ×	.7492=	2719.60	2771.64	2485.47	2196.69	1651.91	116.00
6=	130 ×	26.50=	3445 ×	.9255=	2499.34	5692.85	5257.11	4682.16	3848.60	1767.91
4=	126 ×	25.50=	3213 ×	.6931=	2226.93	4	4	4	4	4.75
2=	122 ×	21.50=	2623 ×	.6478=	1819.17	22771.40	21028.44	18728.64	15394.40	8379.57
Keel=	120 ×	0.87=	104 ×	. 0=	104.00					

Centre of Gravity.

No.	Dec.	Length.			Fore Body.					
16=	580 ×	133=	77.14	Distance	20=	.588 ×	133=	78.20=	133=	54.88
14=	.596 ×	133=	79.26	After	26=	.600 ×	132=	79.20=	132=	52.80
38=	.622 ×	133=	82.72	Body	32=	.612 ×	130=	79.56=	130=	50.44
60=	.643 ×	133=	85.72	from Aft.	42=	.625 ×	126=	78.75=	126=	47.25
100=	.670 ×	133=	89.11		60=	.643 ×	122=	78.44=	122=	43.56

After Body.

Feet.			
22771.40 ×	77.14=	1756585.79	
21028.44 ×	79.26=	1666714.16	
18728 44 ×	82.72=	1549233.10	
15394.40 ×	85.72=	1319608.06	
8379.57 ×	89.11=	746703.48	
86302.45 ÷		7038844.59	(81.56

Centre of gravity abaft middle.

86302.45)7038844.59(81.56
.133

Forward of Sternpost, 81.56

Abaft the middle, 51.44

Fore Body

Feet.		
22241.40	54.80	1218828.72
20875.76	52.80	1102245.92
18905.02	50.44	953569.20
16184.40	47.25	764712.90
9135.05	43.56	397922.77
87341.63÷		4437279.51=50.80

Centre of gravity forward middle.

87341.63)4437279(50.80
Forward middle, 50.80
133.00
Forward Sternpost, 183.80

A. 86302.45× 81.56=7038845.82
F. 87341.63×183.80=6053391.59

173644.08÷ 23092237.41=133

Centre of gravity before centre.

Load Water-Line.

Feet.	Dist.		
5560.35×	187.80=	1044233.73 F	
5692.85×	77.14=	439146.44 A	133
			131.82
11253.20÷		1483380.17(	1.18

35)173644(4961 Tons.
Keel—1312 37.5

174956 499.85 Total tons.

PROPELLER No. 2. ESTIMATES. 2300.

Weight of Hull,	2415
Guns and Carriages,	200
Powder and Shot,	136
Weight of 800 men, etc.,	100
80,000 gallons of Water,	286
Tanks and Water-casks,	120
Provisions, six months,	200
Wood, fifty cords,	112
Purser's Stores, etc.,	125
Masts and Spars,	95
Rigging and Blocks,	80
Cables and Anchors,	120
Gunners' Stores,	40
All other Stores,	75
Boats and Gear,	11
Engines, Boilers, and Bunkers,	350
Coal for twenty days,	650
Total tons,	5115

Hull,	2415
Equipment, Stores, etc.,	1700
Engines, Boilers, Coals, etc.,	1000
Total displacement,	5115

POSITION OF STOWAGE, PROPELLER No. 2.

	Tons.	Disl.	
Anchors,	10	× 19	= 190
Magazine, etc.,	12	× 33	= 396
Water, Provisions,	600	× 70	=42,000
Shells,	57	× 95	= 5,415
Chain,	90	× 100	= 9,000
Cables, Hemp,	20	× 125	= 2,500
Boilers,	100	× 122	=12,200
Coals,	150	× 126	=18,900
Do.,	500	× 153	=76,500
Engines,	200	× 170	=34,000
Shell-Room,	57	× 200	=11,400
Spirit-Room,	150	× 210	=31,500
Tanks and Water,	100	× 222	=22,200
Store-Room and Magazine,	50	× 230	=16,500
Shaft, etc.,	30	× 230	= 9,600
Bread, etc.,	10	× 250	= 2,500
Propeller, etc.,	15	× 270	= 3,950

2167)2973.51(137 feet.

Centre of weight.

137 feet from fore, or 4 feet abaft centre.

TABLE OF COMBINATION OF NUMBERS SUITABLE FOR MERCHANT VESSELS OF GREAT CAPACITY.

No.		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
		The Numbers and Decimals of the Water-Line.					
5th	Aft	7= 8645	8=.8555	9=.8470	10=.8390	11=.8314	12=.8242
	Fore	10=.8390	11=.8314	12=.8242	14=.8110	16=.7988	18=.7884
4th	Aft	10=.8390	12=.8242	14=.8110	16=.7988	18=7884	21=.7718
	Fore	14=.8110	15=.8048	16=.7988	18=.7884	20=7768	25=.7335
3d	Aft	14=.8110	16=.7988	20=.7768	24=.7579	28=7409	32=.7255
	Fore	18=.7884	21=.7718	24=.7579	27=.7450	30=7330	33=.7219
2d	Aft	22=.7620	25=.7535	30=.7330	35=.7150	40=6991	50=.6710
	Fore	23=.7599	26=.7492	30=.7330	35=.7150	40=6991	45=.6845
1st	Aft	40=.6991	50=.6710	60=.6478	70=.6267	80=6081	90=.5940
	Fore	30=.7330	40=.6991	50=.6710	60=.6478	70=6267	80=.6081
Mean Decimal		.7906	.7759	.7600	.7444	.7302	.7165
Multipliers							
.9119	⊕	No. 3=.726	⊕ No. 3=.707	⊕ No. 3=.693	⊕ No. 3=.679	⊕ No. =.665	⊕ No. 3=.654
.9009	⊕	4=.712	⊕ 4=.698	⊕ 4=.684	⊕ 4=.670	⊕ =.657	⊕ 4=.645
.8904	⊕	5=.703	⊕ 5=.690	⊕ 5=.676	⊕ 5=.662	⊕ =.649	⊕ 5=.637
.8804	⊕	6=.696	⊕ 6=.683	⊕ 6=.669	⊕ 6=.655	⊕ =.642	⊕ 6=.630
.8709	⊕	7=.688	⊕ 7=.675	⊕ 7=.661	⊕ 7=.648	⊕ =.635	⊕ 7=.623
.8619	⊕	8=.681	⊕ 8=.668	⊕ 8=.654	⊕ 8=.641	⊕ =.629	⊕ 8=.617
.8534	⊕	9=.674	⊕ 9=.661	⊕ 9=.647	⊕ 9=.634	⊕ =.623	⊕ 9=.611
.8454	⊕	10=.668	⊕ 10=.655	⊕ 10=.642	⊕ 10=.629	⊕ 1=.618	⊕ 10=.605
.8379	⊕	11=.662	⊕ 11=.649	⊕ 11=.636	⊕ 11=.623	⊕ 1=.612	⊕ 11=.600
.8309	⊕	12=.656	⊕ 12=.644	⊕ 12=.630	⊕ 12=.617	⊕ 1=.606	⊕ 12=.595
.8244	⊕	13=.650	⊕ 13=.639	⊕ 13=.625	⊕ 13=.612	⊕ 1=.601	⊕ 13=.590
.8184	⊕	14=.645	⊕ 14=.634	⊕ 14=.621	⊕ 14=.609	⊕ 1=.597	⊕ 14=.586
.8128	⊕	15=.641	⊕ 15=.630	⊕ 15=.617	⊕ 15=.605	⊕ 1=.593	⊕ 15=.582
.8075	⊕	16=.637	⊕ 16=.626	⊕ 16=.613	⊕ 16=.601	⊕ 1=.589	⊕ 16=.578
.8025	⊕	17=.634	⊕ 17=.622	⊕ 17=.609	⊕ 17=.597	⊕ 1=.585	⊕ 17=.574
.7977	⊕	18=.630	⊕ 18=.618	⊕ 18=.606	⊕ 18=.594	⊕ 1=.582	⊕ 18=.571
.7931	⊕	19=.627	⊕ 19=.614	⊕ 19=.603	⊕ 19=.590	⊕ 1=.579	⊕ 19=.568
.7877	⊕	20=.623	⊕ 20=.610	⊕ 20=.598	⊕ 20=.586	⊕ 2=.575	⊕ 20=.564
.7845	⊕	21=.620	⊕ 21=.608	⊕ 21=.596	⊕ 21=.583	⊕ 2=.572	⊕ 21=.562
.7805	⊕	22=.617	⊕ 22=.605	⊕ 22=.593	⊕ 22=.581	⊕ 2=.569	⊕ 22=.559
.7767	⊕	23=.613	⊕ 23=.602	⊕ 23=.590	⊕ 23=.578	⊕ 2=.566	⊕ 23=.556
.7729	⊕	24=.610	⊕ 24=.599	⊕ 24=.587	⊕ 24= 575	⊕ 2=.564	⊕ 24=.553
.7693	⊕	25=.608	⊕ 25=.596	⊕ .5=.584	⊕ 25=.572	⊕ 2=.561	⊕ 25=.551

TABLE OF COMBINATION OF NUMBERS SUITABLE FOR STEAM-VESSELS, MEDIUM AND VERY SHARP. ALSO SUITABLE FOR CLIPPER-SHIPS.

No.		No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
		The Numbers and Decimals of the Water-Line.					
5th	Aft	13=.8171	14=.8110	15=.8048	16=.7988	17=.7930	18=.7874
	Fore	20=.7768	25=.7535	30=.7330	35=.7150	40=.6991	45=.6845
4th	Aft	24=.7579	27=.7450	30=.7330	35=.7150	40=.6991	45=.6845
	Fore	30=.7330	35=.7150	40=.6991	45=.6845	50=.6710	55=.6585
3d	Aft	36=.7117	40=.6991	50=.6710	60=.6478	70=.6267	80=.6081
	Fore	36=.7117	40=.6991	50=.6710	60=.6478	70=.6267	80=.6081
2d	Aft	65=.6478	70=.6267	80=.6081	90=.5940	100=.5282	110=.5670
	Fore	60=.6478	70=.6267	80=.6081	90=.5940	100=.5282	110=.5670
1st	Aft	100=.5282	110=.5670	120=.5560	130=.5480	140=.5340	150=.5230
	Fore	90=.5940	100=.5282	110=.5670	120=.5560	130=.5480	140=.5340
Mean Decimal		.6926	.6771	.6651	.6500	.6254	.6222
Multipliers.							
.9119	⊕	No. 3=.631	⊕ No. 3=.617	⊕ No. 3=.606	⊕ No. 3=.592	⊕ No. 3=.570	⊕ No. 3=.567
.9009	⊕	4=.623	⊕ 4=.610	⊕ 4=.599	⊕ 4=.585	⊕ 4=.563	⊕ 4=.560
.8904	⊕	5=.615	⊕ 5=.602	⊕ 5=.592	⊕ 5=.578	⊕ 5=.556	⊕ 5=.554
.8804	⊕	6=.609	⊕ 6=.595	⊕ 6=.585	⊕ 6=.571	⊕ 6=.550	⊕ 6=.547
.8709	⊕	7=.603	⊕ 7=.589	⊕ 7=.579	⊕ 7=.565	⊕ 7=.544	⊕ 7=.541
.8619	⊕	8=.597	⊕ 8=.583	⊕ 8=.573	⊕ 8=.560	⊕ 8=.539	⊕ 8=.536
.8534	⊕	9=.591	⊕ 9=.577	⊕ 9=.567	⊕ 9=.555	⊕ 9=.533	⊕ 9=.530
.8454	⊕	10=.585	⊕ 10=.572	⊕ 10=.562	⊕ 10=.550	⊕ 10=.528	⊕ 10=.525
.8379	⊕	11=.580	⊕ 11=.567	⊕ 11=.557	⊕ 11=.545	⊕ 11=.523	⊕ 11=.520
.8309	⊕	12=.575	⊕ 12=.562	⊕ 12=.552	⊕ 12=.540	⊕ 12=.519	⊕ 12=.517
.8244	⊕	13=.571	⊕ 13=.558	⊕ 13=.548	⊕ 13=.536	⊕ 13=.515	⊕ 13=.514
.8184	⊕	14=.566	⊕ 14=.554	⊕ 14=.544	⊕ 14=.532	⊕ 14=.511	⊕ 14=.511
.8128	⊕	15=.562	⊕ 15=.550	⊕ 15=.540	⊕ 15=.528	⊕ 15=.507	⊕ 15=.508
.8075	⊕	16=.558	⊕ 16=.546	⊕ 16=.536	⊕ 16=.524	⊕ 16=.503	⊕ 16=.505
.8025	⊕	17=.555	⊕ 17=.542	⊕ 17=.532	⊕ 17=.521	⊕ 17=.501	⊕ 17=.502
.7977	⊕	18=.552	⊕ 18=.539	⊕ 18=.529	⊕ 18=.518	⊕ 18=.498	⊕ 18= 498
.7931	⊕	19=.549	⊕ 19=.536	⊕ 19=.527	⊕ 19=.516	⊕ 19=.496	⊕ 19=.494
.7877	⊕	20=.545	⊕ 20=.534	⊕ 20=.525	⊕ 20=.513	⊕ 20=.492	⊕ 20=.490
.7845	⊕	21=.542	⊕ 21=.532	⊕ 21=.522	⊕ 21=.510	⊕ 21=.490	⊕ 21=.488
.7805	⊕	22=.540	⊕ 22=.530	⊕ 22=.519	⊕ 22=.507	⊕ 22=.488	⊕ 22=.486
.7767	⊕	23=.537	⊕ 23=.527	⊕ 23=.516	⊕ 23= 505	⊕ 23=.485	⊕ 23=.483
.7729	⊕	24=.536	⊕ 24=.523	⊕ 24=.513	⊕ 24=.502	⊕ 24=.483	⊕ 24=.480
.7693	⊕	25=.532	⊕ 25=.520	⊕ 25=.511	⊕ 25=.500	⊕ 25=.481	⊕ 25=.478

TABLE OF COMBINATION OF NUMBERS SUITABLE FOR VESSELS OF THE MOST ATTENUATED FORMS AND OF THE LEAST CAPACITY—YACHTS, ROW-BOATS PLEASURE-BOATS, ETC.

No.		No. 13.	No. 14.	No. 15.	No. 16.	No. 17.	No. 18.
		The Numbers and Decimals of the Water-Line.					
5th	Aft	20=.7768	22=.7620	24=.7579	28=.7409	32=.7255	36=.7117
	Fore	50=.6710	55=.6585	60=.6478	65=.6348	70=.6267	75=.6172
4th	Aft	50=.6710	55=.6585	60=.6478	65=.6348	70=.6267	75=.6172
	Fore	60=.6478	65=.6348	70=.6267	80=.6081	90=.5940	100=.5782
3d	Aft	90=.5940	100=.5782	110=.5670	120=.5560	130=.5480	140=.5340
	Fore	90=.5940	100=.5782	110=.5670	120=.5560	130=.5480	140=.5340
2d	Aft	120=.5560	130=.5480	140=.5340	150=.5230	165=.5175	180=.4900
	Fore	120=.5560	130=.5480	140=.5340	150=.5230	160=.5120	170=.5010
1st	Aft	160=.5120	170=.5010	180=.4900	190=.4809	205=.4670	220=.4560
	Fore	150=.5230	165=.5175	180=.4900	195=.4775	210=.4680	220=.4560
Mean Decimal		.6101	.5984	.5862	.5735	.5613	.5495
Multipliers							
.9119	⊕	No. 3=.556	No. 3=.545	No. 3=.534	No. 3=.522	No. 3=.511	No. 3=.501
.9009	⊕	4=.549	4=.538	4=.528	4=.516	4=.505	4=.495
.8904	⊕	5=.543	5=.532	5=521.	5=.510	5=.499	5=.489
.8804	⊕	6=.537	6=.526	6=.515	6=.504	6=.494	6=.484
.8709	⊕	7=.531	7=.521	7=.510	7=.499	7=.489	7=.479
.8619	⊕	8=.525	8=.515	8=.505	8=.494	8=.484	8=.474
.8534	⊕	9=.520	9=.510	9=.500	9=.489	9=.479	9=.469
.8454	⊕	10=.515	10=.505	10=.495	10=.484	10=.474	10=.464
.8379	⊕	11=.511	11=.501	11=.491	11=.480	11=.470	11=.460
.8309	⊕	12=.506	12=.497	12=.487	12=.476	12=.466	12=.456
.8244	⊕	13=.502	13=.493	13=.483	13=.472	13=.462	13=.452
.8184	⊕	14=.499	14=.489	14=.479	14=.469	14=.459	14=.449
.8128	⊕	15=.495	15=.486	15=.476	15=.466	15=.456	15=.446
.8075	⊕	16=.492	16=.483	16=.473	16=.463	16=.453	16=.443
.8025	⊕	17=.489	17=.480	17=.470	17=.460	17=.450	17=.441
.7977	⊕	18=.486	18=.477	18=.467	18=.457	18=.447	68=.438
.7931	⊕	19=.483	19=.474	19=.464	19=.454	19=.444	19=.435
.7877	⊕	20=.480	20=.471	20=.461	20=.451	20=.441	20=.432
.7845	⊕	21=.478	21=.469	21=.459	21=.449	21=.439	21=.430
.7805	⊕	22=.476	22=.467	22=.457	22=.447	22=.437	22=.428
7767	⊕	23=.473	23=.464	23=.454	23=.445	23=.435	23=.426
.7729	⊕	24=.472	24=.462	24=.452	24=.443	24=.433	24=.424
.7693	⊕	25=.469	25=.460	25=.450	25=.441	25=.431	25=.422

Upper deck

Middle deck

Sheer Plan

Stem of N.º 19

Stem of N.º 1

The fore edge of rabbet of the Stem & the after edge of rabbet of the Post, is governed by the length of the Load line

Upper deck line

Middle deck line

Water line

Water line

Water line

Water line

Water line

Water line

Plain for Columns N.º1

Table of Combination of Numbers

Upper deck

Middle deck

5th Water Line aft at N.º9

5th Water Line aft at N.º7

5th Water Line forward at N.º10

4th Water Line forward at N.º14

1st Water Line forward at N.º15

2nd Water Line aft & forward at N.º13

For Column N.º1

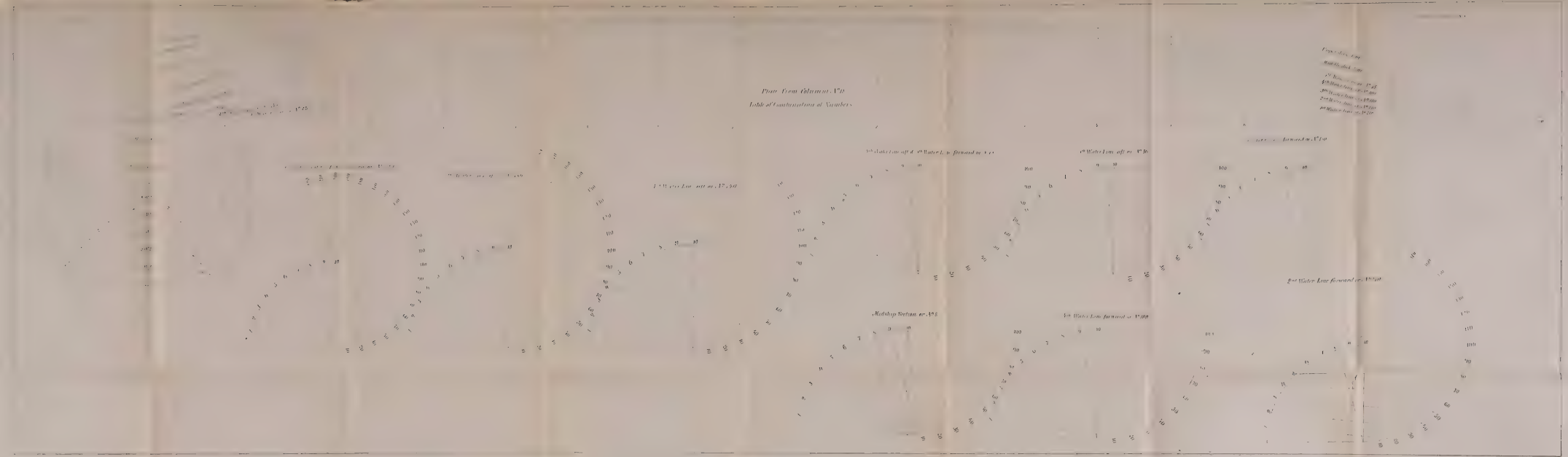


TABLE FOR CALCULATING THE DECIMAL OF CAPACITY AND DISTANCE, FROM THE CENTRE OF GRAVITY FROM THE APEX OF EACH LINE.

No.	W. L.	⊕	Angle Degrees.	Distance.	No.	W. L.	⊕	Angle Degrees.	Distance.	No.	W. L.	⊕	Angle Degrees.	Distance.	No.	W. L.	⊕	Angle Degrees.	Distance.
			° ′					° ′					° ′					° ′	
1	.9090	.9690	3.25	.542	25	.7535	.7693	17.00	.599	47	.6790	.7102	24.00	.630	69	.6287	.6779	.....	.651
4	.8950	.8986	4.50	.546	26	.7492	.7657	17.05	.600	48	.6736	.7082	24.25	.631	70	.6267	.6768	.....	.652
5	.8840	.8886	5.75	.550	27	.7450	.7623	18.00	.602	49	.6727	.7063	24.50	.632	71	.6248	.6758	.....	.653
6	.8740	.8790	6.25	.554	28	.7409	.7590	18.05	.604	50	.6710	.7044	24.75	.633	72	.6229	.6748	23.00	.654
7	.8645	.8701	7.50	.559	29	.7367	.7558	19.00	.606	51	.6685	.7026	25.00	.634	73	.6210	.6738	.....	.655
8	.8555	.8616	7.75	.560	30	.7330	.7527	19.25	.608	52	.6660	.7008	25.25	.635	74	.6169	.6728	.....	.656
9	.8470	.8536	8.38	.563	31	.7292	.7497	19.75	.610	53	.6638	.6991	25.50	.636	75	.6172	.6719	.....	.656
10	.8390	.8460	9.00	.566	32	.7255	.7468	20.00	.612	54	.6610	.6974	25.75	.637	76	.6155	.6710	.....	.657
11	.8314	.8388	9.50	.569	33	.7219	.7440	20.25	.614	55	.6585	.6958	26.00	.638	77	.6135	.6701	.....	.657
12	.8242	.8320	10.00	.572	34	.7184	.7412	20.50	.616	56	.6561	.6942	26.25	.639	78	.6117	.6692	.....	.658
13	.8171	.8256	10.75	.574	35	.7150	.7385	20.75	.618	57	.6537	.6927	26.50	.640	79	.6099	.6683	.....	.659
14	.8110	.8195	11.50	.576	36	.7117	.7358	21.00	.620	58	.6514	.6912	26.75	.641	80	.6081	.6675	.....	.660
15	.8048	.8137	12.00	.578	37	.7085	.7332	21.25	.621	59	.6491	.6898	27.00	.642	82	.6045	.6659	.....	.661
16	.7988	.8032	12.50	.580	38	.7053	.7306	21.50	.622	60	.6478	.6870	28.00	.643	84	.6009	.6443	.....	.662
17	.7930	.8030	13.00	.582	39	.7022	.7281	21.75	.623	61	.6434	.6858	28.01	.643	86	.5974	.6227	.....	.663
18	.7874	.7988	13.50	.584	40	.6991	.7256	22.00	....	62	.6422	.6846	28.02	.644	88	.5946	.6611	.....	.664
19	.7820	.7975	14.00	.586	41	.6951	.7232	22.25	.624	63	.6390	.6834	28.03	.645	90	.5940	.6611	.....	.665
20	.7768	.7891	14.50	.588	42	.6931	.7208	22.50	.625	64	.6369	.6823	28.04	.646	92	.5908	.6595	.....	.666
21	.7718	.7449	15.00	.590	43	.6902	.7186	22.75	.626	65	.6348	.6812	28.05	.647	94	.5879	.6579	.....	.667
22	.7620	.7809	15.50	.592	44	.6875	.7164	23.00	.627	66	.6327	.6801	28.06	.648	96	.5874	.6565	.....	.668
23	.7599	.7769	16.00	.594	45	.6845	.7143	23.25	.628	67	.6307	.6790	28.07	.649	98	.5819	.6551	.....	.669
24	.7579	.7730	16.50	.596	46	.6817	.7122	23.75	.629	68	.6287	.6779	28.08	.650	100	.5782	.6537	.....	.670

Note.—The Angle is an approximation to the rise of floor, when the load water-line is assumed at two fifths the breadth above the base-line.

TABLE SHOWING COMPARATIVE FORM OF FOLLOWING SHIP'S NUMBERS REPRESENTING WATER-LINES AFT AND FORWARD.

No.	Names of Vessels.	⊕	5.		4.		3.		2.		1.		Dec.	Remarks.
			A.	F.	A.	F.	A.	F.	A.	F.	A.	F.		
1	Ohio, 74,.....	16	12	14	22	24	34	30	60	48	100	100	577	Full at lead line.
2	Frigate Scale,.....	30	12	15	20	18	40	35	80	60	100	80	542	Very full.
3	Franklin, 74,.....	28	8	12	16	16	28	26	48	40	90	70	502	Very good.
4	Sloop Scale, ...	50	14	20	30	30	55	45	80	60	100	80		Good frigate.
5	World's Fair,.....	50	16	28	30	35	50	50	65	65	75	90		Excellent.
6	Virginia, altered 1854,..	22	13	24	24	34	48	50	80	70	100	100		
7	Congress, New,.....	30	11	14	20	22	46	34	90	54	100	85	550	Rather full.
8	Congress, Old,.....	55	16	18	30	28	55	44	90	90	100	100	480	Very good.
9	President,.....	46	20	16	38	24	70	40	100	65	100	100	502	" "
10	Constitution,.....	44	16	16	32	24	60	40	100	65	100	100		" "
11	Big Scale, 4 No.,.....	80	17	25	35	35	60	50	80	60	100	80	463	" "
12	Cumberland, ...	36	10	43	20	20	36	28	65	42	100	70		Full at L. W. line.
13	Sloop No. 5,.....	100	20	30	40	45	70	60	90	70	100	80		Slack aft.
14	Portsmouth, ...	40	16	15	30	22	80	32	90	75	90	95	454	Very good.
15	Plymouth,.....	50	16	18	30	28	60	42	100	60	100	76		" "
16	Jamestown,.....	38	7	28	14	36	26	46	46	55	60	65		Slack fore.
17	Albany,.....	100	18	30	40	38	75	48	100	55	100	65		Slack aft.
18	Germantown,.....	75	16	20	28	32	55	50	90	60	100	70		Very good.
19	Saratoga,.....	42	12	17	26	28	55	42	80	65	100	90	486	Fair.
20	B. Spark, ...	100	30	32	60	48	100	65	100	80	100	100		"
21	Princeton, 1850,.....	40	18	46	34	60	55	80	80	100	80	100		Very good.
22	Witchcraft,.....	22	20	42	30	55	46	70	65	90	80	100		Properly balanced.
23	Gamecock,.....	50	20	55	34	70	48	90	55	100	55	100		6 in. by the head.

24	H. Irving,	6	12	14	18	18	26	24	36	32	42	42		Goddard.
35	Vancouver,	12	16	24	24	32	26	44	53	55	72	70		Bacon.
26	Samosset,	10	6	11	12	16	20	24	32	34	50	50		Hall.
27	Beatrice,	5	9	12	16	18	28	24	48	40	80	65		Delano.
28	Barque,	11	11	26	20	36	40	50	65	75	85	100		Hall, fast.
29	Clipper,	12	22	55	40	70	60	90	80	100	100	100		Very good.
30	John Taylor,	6	11	16	16	20	22	26	26	35	40	48		Cotton Ship.
31	Propeller,	22	18	26	34	36	55	46	80	60	70	70		Roger Wall.
32	World's Fair,	22	18	36	30	46	50	60	70	80	80	100		Clipper Ship.
33	Mermaid,	28	18	45	34	55	55	70	70	85	100	100		" Barque.
34	Model,	3	16	26	28	34	46	46	65	65	100	100		Very good
35	Race Horse,	24	18	40	32	46	55	60	70	70	65	70		Hall.
36	Steamer Bill,	8	18	30	36	40	50	60	80	80	100	100		I. M. P.
37	Black Squall,	8	10	20	20	30	32	44	46	60	80	90		Good.
38	Northern Light,	16	15	31	27	40	42	56	56	80	80	80		Excellent.
39	Propeller,	4	14	42	22	55	40	70	60	80	80	100		Model Made.
40	"	22	20	26	34	36	50	48	70	60	80	80		Copeland.
41	Sea Witch,	22	25	45	36	55	60	70	85	85	100	100		N. York.
42	Halifax,	18	42	60	60	70	90	85	100	100	100	100		O. Centre.
43	Cutter,	70	Base to Rail	12 ft.	6 ft. up 24	50	4 ft. 50	70	90	90	100	100		" "
44	Proposed,	20	12	32	28	50	55	70	90	90	100	100		Sloop of War.
45	Brig,	50	16	30	30	50	55	70	90	90	100	100		
46	Sloop,	50	16	28	30	40	50	50	70	90	90	90		Very Good.

Models have been made to all these.

The above table shows the comparative shape of several vessels compared with the numbers representing the curvatures of the several water-lines. The load water-line being in all cases two fifths of the moulded breadth above the base-line, and divided into five equal lines, from the base-line to the load water-line, the midship-frame being two fifths of the length between the perpendiculars abaft the forward perpendicular.

MOULD-LOFT DIRECTIONS.

TOOLS.

It is presumed that your model is carefully prepared and a suitable place is found for the purpose of laying-off; that you have several battens of white or yellow pine—one, of one and a quarter inch square, reaching the whole length of the loft; one, of one inch square; one, of three quarters of an inch square; and twenty or more, of about half an inch square, of the length around the midship section of the model. You have a scale, hammer, saws, wooden square, say with arms ten feet long; also two straight-edges, one ten feet long, and one fifteen feet long; chalk-lines, red and white chalk, nails, one large pair of compasses, one pair of small compasses, and one pair of dividers, and an iron square. You want two measuring-poles, divided into feet and inches, one ten feet long, and one half the breadth of the vessel you intend to draught. You want four dozen scratch-awls, for holding in battens while bending; also a frame for bevellings, to be described hereafter; a pair of wooden horses and a board, made perfectly smooth, for draughting.

Your model is presumed to be made in water-line lifts, and is to be taken apart, although some prefer to glue them together and take the measurements from the outer edges, putting the model in a frame for the purpose.

Before taking the model apart, lay out the distances between the centre of the frames, on the back of it; square these lines across each lift separately, after it is apart, and with your scale take off measurements or distances to an eighth of an inch, and put them in a table previously prepared for the purpose.

We will assume the dimensions to be in accordance

with the drawing, which is on a scale of three eighths of an inch to the foot.

To be, Length, ... 150 feet.
Breadth, ... 29′ 6″
Depth, ... 18′ 7″

The spaces or distances between the centres of the frames will be twenty-six and one half inches. We will take off the ⊠ or midship section first, and take off the remaining distances forward and aft of these in two tables, one for the forward body or the part before the ⊠, and the other for the after-body. The first table, the sections or frames will read ⊠ A. B. C. D., etc. ; in the second table they will read 1, 2, 3, 4, 5, 6.

Heights of the Sheer above the 7th Water-Line.	Names of Frames.	Name of Water-Line. 1st W. L.	2d W. L.	3d W. L.	4th W. L.	5th W. L.	6th W. L.	7th W. L.	1st Sheer.	2d Sheer.
	⊠									
	A.									
	B.									
	C.									

In these columns are inserted the half-breadths of all the frames, taken from the model by a scale, prepared for the purpose, in feet, inches, and one eighths.

The measurements being taken off very accurately from the model, much of your labor depends upon the accuracy of this part of your work ; if your scale is large enough, take off your measurements to one sixteenth of an inch.

ON THE FLOOR.

First make a base-line the whole length of the loft ; from this, erect square or perpendicular lines at the distances apart of the frames, say twenty-six and a half inches ; set up from this base-line the height between the

horizontal or water-lines, say twenty-one inches; above the horizontal lines set off the height of the sheer on the midship frame. Now take the half-breadth of the midship frame from your table just obtained from the model, and as you set them off from a perpendicular line which you assume for the centre line of your body-plan, you insert the point of the scratch-awl into each measurement, leaving it there. Set off the half-siding of the keel on the base-line, say six inches from the centre line.

We will now take the dead rise or angle of the floor from the centre line of the model upward, and measuring the distance up from the base-line at one fourth of the breadth, generally draw a straight line, if the floor is straight, to the back of the curve drawn at the half siding of the keel for the thickness of the bottom plank, say four inches; the base-line of the model being usually at the top of the keel; set down below the base-line the thickness of the bottom plank, with one point of the dividers in this point, and open to the thickness of the bottom plank; scribe downward and inward, making the back of a curve upon which the square frames in the body-plan will end. Now lay a straight-edge to the line just struck for the dead rise, and take one of the half-inch battens and pin it to the spots just set off, and make this perfectly fair in every direction.

Take from the tables the height of the sheer, and assuming your base-line to be your upper water-line, after having set off the heights leave your points sticking into the spots; bring your largest batten to these points, and make that perfectly fair—the whole length of the ship—(in going from the forward to the after-body, when your loft will allow, always have a lap of at least ten frames.) Having faired your sheer, now take off the heights with a batten on each frame the whole length of the ship, and

set them off in the body-plan at the centre-line and at the side or half-breadth line; then take your chalk-line and level out lines, one for each frame, (it is always best to lay down both ends of the ship at the same time, when your loft will allow it.) So we presume you will lay out your midship section both sides of the centre-line; one will be used for the forward-body and one for the after-body, and great care must be taken to get both sides exactly alike; next look at the moulding sizes which you intend to make the frames; take from your notes the depth of floors, size at bilge and at sheer heights, and with a true taper set off all intermediate sizes; proceed to draw a line through these last points, altering it as judgment may dictate for the moulding sizes of the frames. This may be taken off at each sirmark or bevelling-spots in inches and eighths from the keel to the rail, and laid away; set off all the measurements in the table, both forward and aft, and draw in every frame, so taken off, by itself, using the batten and points, as in the midship frame. The shape of the body-plan is now laid out, in square frames.

Proceed to take off from your table the shape of the stem.

Get the height of the sheers on the stem from the model very accurately, and set that point above the base-line assumed, in some convenient place in the loft where you will have room enough to lay out your head forward of and deadwoods aft of it, to the forward square frame; after setting off all the spots, now draw a fair line coming fair with the base-line; you cannot be too careful in shaping this line, as the whole symmetry of the bow often depends on the shape of the stem.

Proceed now to lay off the rabbet of the stern-post from the model, and the shape of the midship counter,

taking your heights and distance from the model, and setting exactly the same aft from an assumed perpendicular line.

Having obtained this point, proceed to draw in the shape of the midship counter timber and stern-post.

You have now a general outline of your vessel upon the floor; your business is to completely fair every part of this outline so as to make moulds to be used in the ship.

DIAGONAL LINES.

Take your rule and commencing at the centre line near the keel, lay out points three feet apart, all around the ⊠ frame; from these points draw lines in white chalk diagonally toward the centre line, as near as is possible square with the shape of the frame-lines just drawn in the body-plan. Make a flat batten, brought to an edge like a ruler, long enough for the longest line, and, with a piece of white chalk sharpened to an edge, take off the intersections of the frames just drawn in the body, placing one end well with the centre line and keeping the edge to the diagonal line, one at a time, taking the longest one first, which is generally the upper one. After taking off these intersections, proceed to set them off from the base-line which has previously been marked with the names of the frames ⊠. A. B. C. D., etc., which now becomes the centre line of your half-breadth plan; set off these spots, leaving a sticker or scratch-awl in each point until you come to the ending. To obtain the ending take a batten to the body-plan, place it vertically one end to the base line, and the edge to the half-siding of the keel, take the intersection of the diagonal just taken off with the half-siding, go with this height to your stem-line, place one end to the base-line, and with the height ob-

tain an intersection square from the base-line on the line drawn for the stem; level a line forward, and with a rule set forward the thickness of the bottom-plank on a square from the point of intersection just found; square that down to the centre-line of the half-breadth plan. Now go back to your body-plan, and with your rule measure the diagonal distance from the centre-line to the half-siding of the stem; go back again to your half-breadth plan, and set off this distance square from the centre-line; make a spot; take a pair of compasses, set off in your body-plan the thickness of the bottom-plank at the stem—it will be a line parallel with the half-siding of the stem; now with your rule take off the distance on the diagonal line from the side-line to the line just drawn for the thickness of the bottom-plank. Go back to your half-breadth plan, set this in from the point just squared down from the stem; for the ending of the diagonal, take a pair of dividers, open them to the distance just obtained, sweep aft; your diagonal will end on the back of this sweep. Now pin your batten to all the spots set off and regulate and fair it; when completely fair rub out the chalk-marks from your batten and take off the spots for all the frames in chalk; take these to the body-plan, and laying the batten to the diagonal line, set off the frames; proceed in the same manner with all the diagonal lines. The advantage of taking one line at a time is, you immediately detect an unfair spot in your model from the first line, and you can alter your chalk frames to it at once. You should mark four or five frames which you wish to keep the shape of exact and fair between these spots always. Do not draw any of these diagonal lines in upon the floor, as they are of no use to you except to fair the frames.

RIBBAND-LINES.

It sometimes happens that the loft is not wide enough to use diagonal lines for the longest lines, so that instead of taking the distances upon the diagonal lines off in a diagonal direction, we take the intersection of the frame with the diagonal square from the centre-line of the body-plan, making a new height at each intersection; set them off in the half-breadth plan the same as before: but the ending is different. Ending of ribband-lines: Square down the ending from the stem-line as before, and at the point of intersection with the half-siding of the stem, with a pair of compasses open to the thickness of the bottom-plank, scribe a half circle as before aft and in from the side-line; the ribband-line ends on the back of this curve. You can draw your ribband lines in the half-breadth plan as far as the forward square frame, as they can be used in proving the cants. The shape of these lines is generally more rounding close to the ends than a diagonal line, and care should be taken not to get them too slack.

SHEER-LINES.

Take your batten, place one end to the centre-line in the body-plan, and with the edge at the ☒ height for the first sheer, take off each half-breadth on the height marked for it, already obtained in the body-plan, set these off in the half-breadth plan on their respective frames, leaving the stickers in the points found in the half-breadth. To obtain the ending, take where the sheer height crosses the stem in the sheer plan, and square that down to centre-line in the half-breadth plan; set forward from this point the thickness of the plank at this place, between these two points, with a pair of compasses; sweep

in toward the centre-line, keeping the forward point as a centre; now end your line on the back of that curve. The sheer lines may be drawn in, in red chalk or pencil, as far as the forward square frame.

Having run off all the ribband and diagonal lines and the sheer-lines, you may set them off in the body-plan, laying the half-breadth poles or battens in the same directions in which they were taken off.

It has been my practice at this stage of the work to proceed to run in all the square frames at once from the diagonal ribband-lines and sheer-lines just run off. The model is presumed to be nearly fair before taking off the measurements; the process just gone through with has insured the fairness of it if we have been careful in running the lines. The frames are run in one line at a time in the same manner as the ⊠ frame was run in. After you have run in your square frames, those frames which are in the cant-bodies are fictitious, and are run in temporarily in white chalk.

CANTS.

Lines have already been drawn in the body-plan 21 inches apart, which represent horizontal or water-lines. Refer to the plan accompanying this, and you will see them marked W. L.

Commence to take these W. Lines off for transferring to the half-breadth plan by placing an end of your half-breadth staff to the centre-line of the body-plan, and with the edge to the water-line take off each intersection of the frames, marking their names with chalk, and set them off on their corresponding frames in the half-breadth plan.

As a general thing, you only want about twenty or thirty feet at each end. In this ship we go back to frame

O in the fore-body; take off of this far enough, however, to obtain a lap of ten frames.

To obtain the ending of the water-line, square down the intersection of the water-line with the stem-line already drawn to the half-siding of the stem; set forward the thickness of the bottom-plank from this line on the line for the siding of the stem in the half-breadth plan, and with this distance taken in a pair of compasses scribe a line inward, making the forward point the centre of the circle; the water-line ends on the back of this curve. In shaping your water-lines, take great care that the ends are not too flat or too round, close to the ends. You have now your water-lines, topside or sheer-lines, and ribband-lines drawn forward of frame O. To lay out your cants, which in a full-bowed ship is necessary in order to save bevel and shape of timber, look first at your stem, and see how far your knight-head must run down for the strength of the bow; having obtained that point, square it down to the half-siding of the deadwood, which is generally the same siding as the stem; this point fixes the forward edge of the forward cant on the side of the deadwood. Now swing a short batten around forward of this point until you come nearly or quite square with the direction of your ribband-lines, and draw a line which will represent the forward edge of the forward cant. Set forward from the centre of the forward square frame S the thickness of the floor timber, a space of three or four inches, and the siding you intend the cants at the heels; this makes a point for the joint of cant **t**. Take the distance on the first sheer height and divide it equally on a square between the forward square frame S and the line drawn for the forward cant Z; draw a line joining the point found on the half-siding of the deadwood and the point just found for the first cant on the first height-

lines; divide the distance equally on a square between this line and the line drawn for the fore-edge of the first cant, and draw in lines which will be the joints of centres of the cants.

Now, to take off these lines, take a half-breadth pole, make one end at the centre-line and lay the edge to the lines just drawn for the joints of the cants in a cant direction, and take off the intersection with the water-lines, sheer-lines, and ribband-lines; take these to the body-plan, and set the water-line spots off each on its respective line; but before you can set off the sheer-lines or diagonal lines, or obtain the endings of the cant-lines, some work remains to be done.

It is necessary now to run in a new line. First, to obtain the true sheer-heights, lay a batten with the end against the forward square frame in the half-breadth plan, and pin it around to the shape of the line to the stem; mark on this batten the intersection of all the square frames.

Now raise this batten to the sheer-line as run from the model, letting the after-end come to the fore-square frame, and the other end extend forward as far as it will, keeping the edge well with the sheer-line, for the raised line. Set off the new station just found for the square frames, take off the heights from the base-line to the new stations, and set them off on the old stations, which will raise the sheer enough to make allowance for the curve of the bow; the height of the stem is obtained by letting the sheer run forward as far as the new length requires, and taking a new height setting it back on the stem; by drawing a new line through all these points, we obtain the exact sheer required for the cants. Now take off the heights for the new sheer, and set them off in the body-plan on the chalk and on the side-line for the stem, and draw a fair line through these points.

New sheer-lines may be taken off as before, and run into the half-breadth plan. Having obtained this new line, take off the distance square from the centre-line at each cant-station at the sheer-lines, and set them off in the body-plan until they strike the line just found there for the sheer; at the point of intersection level out a line; now take of the half-breadths for the sheers in the direction of the cant-lines, and take them to the body-plan, setting the spots off on the lines just squared out, which are the true heights for the cants.

You can now take off your ribband-lines, in the half-breadth; first taking the distance square from the centre-line to the intersection of the cant-line with the ribband-line, take that to the body-plan, and placing one end of your pole to the centre-line, and keeping the edge of your batten level, let the point intersect the diagonal in the body-plan; level out a line at the intersection; now take distance from the centre-line in the half-breadth plan in the direction of the cant, and set off a spot in the line just levelled out for the cant-line in the body-plan.

Proceed now to find the endings in the following manner: Lay a batten well with the half-siding of the deadwood in the half-breadth plan, with the end against the forward square frame and reaching to the upper height; take off the intersection of all the water-lines and sheer-lines with the half-siding of the deadwood, and set them off in their respective heights in the sheer-plan, making a spot; now go to the body-plan and take off the intersections of all the frame-lines with the half-siding of the deadwood above the base-line; take these heights back to the sheer-plan and set off the height in each frame respectively, making a spot; through all these spots draw a fair line, which is the bearding-line upon which all the cants end. Now, from the half-breadth plan square up

the intersections of each cant-line with the half-siding of the deadwood to the sheer plan, crossing the bearding-line just found. These are the stations of the cants fore and aft-ways on the deadwood; take these heights from the base-line to each intersection with the bearding-line and set them off above the base-line in the body-plan; level out lines at the heights just obtained, go back to the half-breadth plan and take on each cant separately the distance from the centre-line to the side of the deadwood in the cant or diagonal direction; go back again to the body-plan with these breadths, and set them off on each height just found respectively.

You have now all the points required for drawing in your cant-lines, and if your work is correct, the line will be perfectly fair through all the spots thus found.

A round stern is lain down exactly in the same manner as has just been described for the bow, the only difference being in the different shape of the lines which custom has made.

To lay down a knight-head and hawse-pieces, set off the thickness of the knight-head, say six inches from the half-siding of the deadwood in the half-breadth plan; with one end of your breadth-pole against the forward square frame, take off the intersections with the water-lines, ribband-lines, and sheer-lines on that line; carry them to the sheer-plan and set off the distances on their respective lines in the sheer plan, making a spot. To obtain the heights of the diagonal lines in the sheer-plan, take with a pole the height of each intersection of the frame with the diagonal line square up in the body-plan; set off those heights in their respective lines in the sheer-plan; drawing a curved line through these spots gives you the position of the diagonal in the sheer-plan; for the ending of the same, square up the point from the half-

breadth plan where the half-siding of the deadwood crosses the ribband-line.

Having set off all the spots for the bevel of the knight-head and knight-head, both obtained in the same manner, you may draw lines through the points just found; now to obtain the ending, square up from the half-breadth plan where the knight-head line intersects the forward edge of the forward cant to the sheer-plan, a perpendicular line from these points in the cut-off for the knight-head and bevel. The operation is the same for the midship counter-timber for a round-sterned ship.

Deadwood or cutting-down lines are obtained by drawing in the moulding sizes of the inside of the frame in the body-plan from the sizes obtained when laying out the ⊠ frame and taking the spot where that crosses the half-siding of the deadwood and setting that up on each frame and cant in the sheer line. If you wish your ceiling to butt against your deadwood, allowance must be made for the thickness of the ceiling in addition to this size.

You have now all the lines ready to make the moulds from for a round-stern ship. Before making the moulds you will see how your timber is to be converted; and no one can say more than, use your judgment, and see that your curved timbers can be obtained without too much expense. It is best generally to make a mould to each futtock separately; it saves confusion and time. When you make your cant-moulds, you want to take the point found for the ending against the deadwood, and draw a line up from this point parallel to the centre-line of the body-plan, which will be the line to cut the cant except what may be added for boxing into the deadwood; when the boxings are cut on the timbers, see that they are bevelled corresponding to the swing of the cant, or you will not be able to box them.

BEVELLINGS.

To take off the bevels of the square body, it is generally near enough to take the distances on a square with the timber from frame to frame at each diagonal; the distance from O. to P., taken on a square not on a diagonal line, being the bevel of O. in the fore-body; the distance from 30 to 31 being the bevel of 30 in the after-body.

Now make a bevelling frame. It consists of two parallel straight-edges secured across the ends, forming a perfect square, at the distance from outside to outside, of the frames from centre to centre, square a line across it. Now have a straight-edge long enough to reach for the longest bevel, pin one end of it at the out edge of the left-hand batten, take the distance from frame O. to P., say on the second diagonal square from the intersection of P. in the body-plan; this being an under or in-square bevel, set it off below the square line; if it was taken from the O. to P., it would be for the bevel of O., it would be an out-square bevel and set above the tongue. Bevels are generally taken off in-square for the square body.

Put a bevel-board under the batten; the sides of your bevel-frame having been made twice as thick as the ends, to admit a bevel-board lying under the tongue. Now laying the tongue to this point and drawing a line on the board, you have the bevel of P. at the second diagonal, for the timber forward of the joint; reverse this bevel or make it an out-square or standing bevel for the timber abaft the joint.

CANT-BEVELS.

In order to obtain the bevel of the cants, take a square, lay it against the cant-line in the direction of the

cant at the point of intersection of the cant-line with the centre-line of the half-breadth plan; draw a line above and below the centre-line, crossing it diagonally; set off six inches each side of the cant-line, and with a chalk-line snap in a line for the bevelling-line, both before and abaft the cant-line. Now take a half-breadth pole and proceed to take off the bevel; the operation is the same as the cant-line except that the end of the pole will come to the line just squared at the centre-line inside the centre-line abaft the joint; outside the centre-line forward of the joint, for the forward cants. All the measurements which are taken off square will be taken from the centre-line of the half-breadth plan.

TO LAY DOWN A SQUARE STERN.

You will have to refer to a model and drawings. Having prepared a square-sterned model, you will commence by laying out the stern counter-timber at the centre taken off from the model; also the round aft-lines taken from the model at the first and second heights; also the shape of the cross-seam drawn in the body-plan.

Now draw in a line in the sheer-plan to represent the fore-side of the inner-post which is to the transoms what a deadwood is to the floor-timbers.

Lay off the water-lines and ribband-lines and frames, as has been described, from the model, also another set of lines called section-lines, which are lines parallel with the centre-line in the body-plan and half-breadth plans; to lay them out in the sheer-plan, it is necessary to square up from the half-breadth plan to the sheer-plan the intersections of all the water-lines with the section-lines on their respective water-lines, making spots for them; also where the lines intersect the cross-seam and after-edge of

a side counter-timber drawn from the model. Now from the body-plan take the heights of the intersections of the square-frames with the section-lines and set them above the base-lines in the sheer-plan on their respective frames; take off the intersection with the cross-seam and half-breadth side counter-timber, also from the body-plan transfer that height to the sheer-plan for a spot, which, intersecting with the point squared up from the half-breadth plan to the sheer-plan, makes the ending for the section-line; draw lines through all these spots, and you have the section lines.

Proceed to space off your transoms, which are generally with not more than two inches between them, and from ten to twelve inches thick; after levelling them out in the sheer-plan, let the lines run forward to intersect the several section-lines which have been drawn. If not, you will draw in section-lines as described previously. Now draw in the edge of every line, both top and bottom of the transoms, in the same manner as the water-lines which form the shape of the upper and lower edge of each transom. The transoms cut off at the forward end square against the aft-side of the fashion-piece, which is the after cant-timber drawn and bevelled as any other cant.

Transoms are often canted, and you dispose of them in the sheer-plan as your judgment may dictate; the whole operation is exactly the same as in taking off all other cants. Your cant-lines must be drawn through to the perpendicular, drawn from the cross-seam to the base-line of the sheer-plan, when that becomes the same as the centre-line of the half-breadth plan. Your section-lines, fashion-piece, base-line, and perpendicular-line being drawn, and a few of the aftermost square frames in the body-plan; lay out the fashion-piece in the body-

plan square; that is, take off the distances square from the centre-line in the half-breadth plan, and set those distances off in the body-plan, and draw a line. Now take the heights in the sheer-plan where the cant transom-lines extended intersect the square frames and section-lines and bearding-lines, and set off those heights in the body-plan; lines drawn through these spots show the heights of the upper and lower edge of the transoms in the body-plan. Now take off the half-breadths at the square frames in the body-plan square to these intersections in the body-plan, and transfer that breadth to the half-breadth plan and make a spot; take now the distance from the perpendicular in the sheer-plan in the direction of the cant-line to the same frames, and take off spots; set off these spots in the half-breadth plan until they intersect the distances set off in the square frames just taken from the body-plan; the point of intersection makes a spot in the line of the transoms.

For the section-lines take the distances in the direction of the cant from the perpendicular in the cant direction, and set them off from the perpendicular in the half-breadth plan on their respective section-lines; lines drawn through these spots give the shape of the transoms. Square up from the half-breadth plan where the fashion-piece crosses the water-lines, and draw a line through all the spots.

Now where the fashion-piece intersects the centre-line in the half-breadth plan, square that up to the sheer-plan and it becomes a line to which you must measure from the after-perpendicular in the sheer-plan taken off in the direction of the cant-lines in the sheer-plan to the point of intersection; set this distance off in the plan of transoms, and draw a line parallel with the cant of the fashion-piece, and you find the line to cut off the mould against the fashion-piece.

The bevels are taken off as in other cants, by squaring the heels against the perpendicular in the sheer-plan and working as before for the transom lines.

Lay down a square stern upon the rake. Space off your counter-timbers at equal distances each side of the centre counter-timber in the body-plan and half-breadth plan, and, from a perpendicular line assumed, take off the distances to the cross-seam line and round of stern-lines drawn from the model; set these distances off in the sheer-plan, extend the lines below the cross-seam and draw in section-lines corresponding with the lines already drawn, far enough to obtain the shape. Where these lines intersect the line drawn for the back of the main transom will be the end to which they will be cut off in making the moulds. The bevels are taken in the same manner by drawing new lines, say six inches, inside of those just drawn. The heights are levelled from the body-plan to the sheer-plan.

To lay down the quarter counter-timber. Having drawn the shape you desire in the body-plan from the model, represent the after-edge of the quarter counter-timber in the sheer, half-breadth, and body-plan from the model.

Assume a straight line in the half-breadth, sheer, and body-plans just inside of the end of the transom, say ten inches, for a centre-line; extend that line below the transom, in the sheer-plan, far enough to extend below the top of main transom at the quarter counter-timber; now square the heel, set off and run in the sheer-plan, body and half-breadth plans, water-lines at the distance of six inches apart at the side of the ship and across the stern. Now, from your line just drawn at the lower end in the sheer-plan for a base, take off the distances on the rake to all the water-lines; level these heights out on the body-

plan at the same line assumed the same distance from the centre; now take off the heights from the same base-line to the intersection with the line drawn for the after-edge of the quarter counter-timber in the sheer-plan; level these heights out in the body-plan; square up from the water-lines in the body-plan from the intersection of the original line to the new water-lines, to the new heights just set off at the quarter counter-timber. Take the distance from the half-breadth plan in the direction of the water-line drawn across the stern, and set it off from the heights in the perpendicular in the body-plan, to intersect the point just squared up; spots drawn through all these points will give the shape of the mould at the outer edge; proceed the same with the fore-edge; for the bevel forward, the bevel aft may be taken off from the floor from the water-lines.

In making your moulds, you make one mould to the rake with the heights and bevels forward from the centre, and another on the rake with the shape of the after-edge of the counter-timber, having the bevels from the after-corner forward and the heights of the stem upon the rake marked upon it.

HARPINGS.

Harpins are generally laid down level or on water-lines where they are most required: it is the simplest and therefore the best method.

Harpins are bevelled by laying down both edges in the half-breadth plan; then taking the distances between the lines on a square for the bevel under, in the distance between the lines, or thickness of harpin.

LAYING DOWN A HARPIN TO A SHEER-LINE.

First lay it down in the half-breadth plan as any other sheer-line. In order to make the mould correctly, take a

batten and lay its edge well with the sheer-line; proceed to mark its intersections with the cants and frame-lines as the batten lies to the curve in the sheer-plan. Keep the forward end fast, and raise the after-end level; from this level line square down the new position of cants, etc., to the half-breadth plan crossing the line laid out for the harpin; level aft-lines from the intersection of the cants and frames with harpin-line in the half-breadth plan, as first laid out, until it intersects the lines just squared down from the sheer-plan; pin a batten to the new points, and draw in a line for the harpin-mould, and mark the last spots for the position of cants and frames when the harpin is bent. It is best to make the harpin-line straight from end to end in laying out the line, in a position on the bow or stern where it will not be moved in running sheer-lines, on the ship after it is in frame.

Half-Breadths. After the moulds are made, properly marked, and bevels all taken off, in order to lay out your frames, take off half-breadths or poles sufficient in number and at points to lay out the moulds; these poles so taken off are called half-breadth poles.

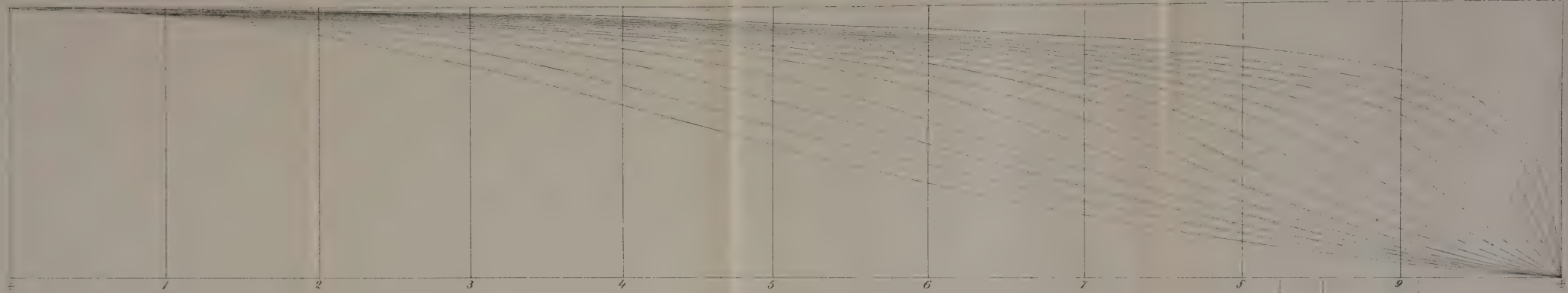
Floor-Moulds. In making your floor-moulds, I prefer the old-fashioned square; take a straight-edge as long as the sirmark requires for the length of the half-floors, and with a tongue as long as the rise of the floor requires; set up the heights taken off from the base-line of the body-plan to the intersection of the frames with the line for the sirmark. Now take off the intersection of the same points from the centre-line to the sirmarks; set these points off both sides of the centre-line of the square; and drawing lines square from the straight lines, we have the intersections to which the moulds are to be laid in moulding the floors. There are other methods; but this is as simple as any.

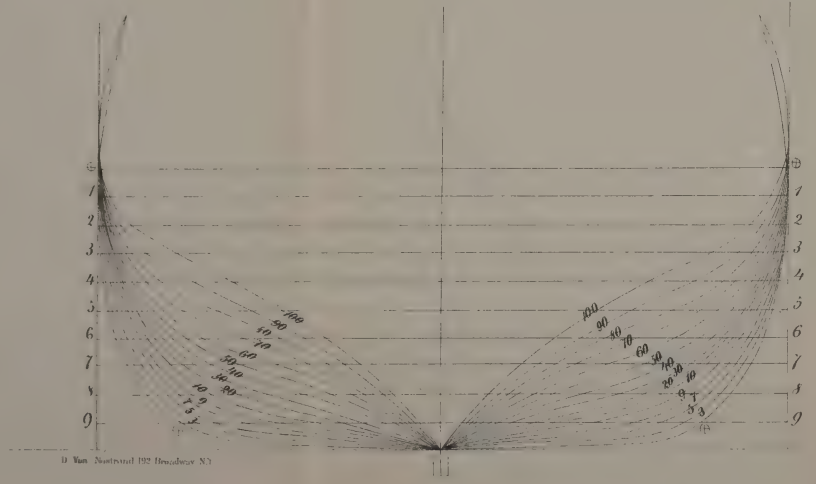
Having laid out all parts of the ship, you are now prepared to make the mould.

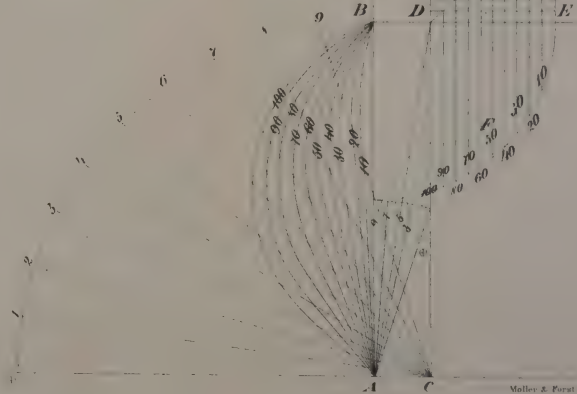
In the above description of laying off, I have only described my method of running off the lines which are absolutely necessary, dispensing with many lines which others often use—"as time is money"—and the sooner the work can be accomplished, provided it is correct, the better it is.

I can only say in conclusion, that nothing is so important in a mould-loft as the two elements of character required of all persons who follow this business; the first is good taste in forming or shaping your lines; and the next, good judgment in running your lines in.

With these characteristics, you will need no more instruction than I have given; without them, all that could be written will not make you an extraordinary draftsman.







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APPENDIX.

SINCE this work has been in press the author has made what he considers a great improvement upon the original diagram ; and in distinction from the first figure, he has called the last the "Wave Line Diagram," inasmuch as this last figure and tables produce lines exactly corresponding to Mr. Rupel's famous wave lines.

WAVE LINE.

Draw a base line and erect a perpendicular, and with the half-breadth of the ship as radius, describe a quadrant to the left hand, mark its intersection with the base line ⊕ and with the perpendicular B.; the centre will be marked A. Now divide the arc into ten equal parts, and number them from 1 to 9, commencing No. 1 near ⊕ and No. 9 being next to B. ; then set off on the right hand of A. B. a line parallel with it, distant equal to B. 9, and mark its intersection with the base line C. and upper end D. Now draw all the lines from 1 to 9, to the point C.; then with the point of your compass fixed at B. and opened to the intersection of C. 9, with perpendicular describe a quadrant to the right hand E. F. Now make a scale of equal parts, dividing D. E. into ten equal parts, and square them down to intersect the quadrant E. F. ; then with the distance F. B. as radius, and the point of your compass fixed at the points of the divisions on E. F., describe an arc of a circle from each point toward the

left hand, and from each arc draw a tangent to intersect A., and number them from 10 to 100. Now measure the distance from the numbers on the quadrant in the direction of the lines drawn to C., to the intersection of the arc and tangent, commencing at No. 100, and proceed as follows: Prepare a sheet of paper, and draw a base line representing the middle line of your ship, erect a perpendicular in the middle of the length between the perpendiculars, and mark it ⊕. Then divide the space from ⊕ to each perpendicular into ten equal parts to correspond with the divisions on the quadrant, and mark them the same, from 1 to 10, and then set off on those lines, from the middle line the measurements taken off from the circumference of the quadrant in the direction of the lines drawn from No. 1 to 9 to C, where the arc and tangent cross them, and set off those measurements from the middle on their corresponding numbers square from the middle line, and a batten bent to the spots so set off will represent the several water or horizontal lines of a ship; these lines can then be measured by a scale of equal parts and the area of each calculated in proportion to its circumscribing parallelogram, and so tabulated; the area of each line being placed opposite each number from 1 to 100, these lines may then be compared with other ships of known good qualities, from which may be selected the proper lines to produce similar ships, and will enable the constructor to select those lines which will produce the vessel required, the value of each line being known.

TABLE OF THE DECIMAL OF EACH NUMBER IN PROPORTION TO ITS CIRCUMSCRIBING PARALLELOGRAM, CALCULATED FOR THE WAVE-LINE DIAGRAM.

1=1.000	19=.786	37=.741	55=.677	73=.610	91=.544
☒= .900	20=.784	38=.738	56=.674	74=.607	92=.540
3= .890	21=.781	39=.735	57=.670	75=.603	93=.536
4= .880	22=.790	40=.733	58=.666	76=.600	94=.532
5= .870	23=.796	41=.729	59=.663	77=.597	95=.528
6= .860	24=.774	42=.725	60=.659	78=.593	96=.524
7= .850	25=.771	43=.722	61=.655	79=.590	97=.520
8= .840	26=.769	44=.718	62=.651	80=.586	98=.516
9= .830	27=.766	45=.714	63=.648	81=.582	99=.512
10= .820	28=.764	46=.711	64=.644	82=.578	100=.508
11= .816	29=.761	47=.707	65=.640	83=.575	102=.500
12= .812	30=.759	48=.703	66=.637	84=.570	104=.492
13= .808	31= 756	49=.699	67=.633	85=.567	106=.484
14= .804	32=.754	50=.696	68=.629	86=.563	108=.476
15= .800	33=.752	51=.692	69=.626	87=.559	110=.468
16= .796	34=.749	52=.688	70=.620	88=.556	112=.460
17= .792	35= 746	53=.685	71=.618	89=.552	114=.452
18= .788	36=.744	54=.681	72=.615	90=.548	116=.444
					118=.436

COMBINATION OF NUMBERS CALCULATED FOR THE WAVE-LINE DIAGRAM. EACH COLUMN MAY BE COMPARED WITH THE FIRST DIAGRAM ON PAGE , FROM WHICH COMPARISON MAY BE SELECTED THOSE LINES MOST PREFERRED BY THE CONSTRUCTOR.

NUMBERS OF COLUMNS.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
5th W. L.	Aft,	5	6	7	8	9	10	11	12	13	14	16	18	20	23	29	29	32	35
	Forward,	10	11	12	15	20	25	30	35	40	45	50	53	56	59	62	65	68	70
4th W. L.	Aft,	9	12	14	16	18	20	23	26	30	34	38	41	44	47	50	53	56	60
	Forward,	14	16	18	20	25	30	35	40	45	50	54	58	61	64	67	70	73	76
3d W. L.	Aft,	17	20	23	26	30	33	36	40	45	48	51	53	55	57	59	61	63	65
	Forward,	20	25	30	35	40	45	50	55	60	65	70	75	80	83	86	89	92	95
2d W. L.	Aft,	35	38	41	45	50	55	60	65	70	75	80	85	90	93	96	100	104	108
	Forward,	35	38	41	45	50	55	60	65	70	75	80	83	86	89	92	95	98	100
1st W. L.	Aft,	50	55	60	65	70	75	80	85	88	91	94	97	100	103	106	109	112	115
	Forward,	40	46	52	58	64	70	76	82	90	95	100	100	100	100	100	100	100	100

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